Report of the South African Association for the Advancement of Science.

Cape Town, 1910.

REPORT

OF THE

EIGHTH ANNUAL MEETING OF THE

SOUTH AFRICAN ASSOCIATION

FOR THE ADVANCEMENT OF SCIENCE.

MARINE BIOLOGICAL LABORATORY
WOODS HOLE, MASS.
LIBRARY

V. 7

CAPE TOWN,

1910.

OCTOBER 31—NOVEMBER 5.

CAPE TOWN:
PUBLISHED BY THE ASSOCIATION.

1911.

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MARINE BIOLOGICAL LABORATORY
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CONSTITUTION

OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

[*As Amended at the Third Annual Meeting at Johannesburg, 1905.*]

I.—OBJECTS.

The objects of the Association are :—To give a stronger impulse and a more systematic direction to scientific enquiry ; to promote the intercourse of societies and individuals interested in Science in different parts of South Africa ; to obtain a more general attention to the objects of pure and applied Science, and the removal of any disadvantages of a public kind which may impede its progress.

II.—MEMBERSHIP.

(*a*) All persons interested in the objects of the Association are eligible for Membership.

(*b*) The Association shall consist of Permanent Members, hereafter called "Members," and Temporary Members, elected for a session, hereafter called "Associates."

(*c*) Members and Associates shall be elected directly by the Council, or by the Managing Committee of Council. Associates may also be elected by Local Committees. Members may also be elected by a majority of the Members of Council resident in that centre at which the next ensuing session is to be held.

(*d*) The Council shall have the power, by a three-fourths vote, to remove the name of anyone whose Membership is no longer desirable in the interests of the Association.

III.—PRIVILEGES OF MEMBERS AND ASSOCIATES.

(*a*) Members shall be eligible for all offices of the Association, and shall receive *gratuitously* all ordinary publications issued by the Association during the year of their admission, and during the years in which they continue to pay, *without intermission*, their Annual Subscription.

(*b*) Associates are eligible to serve on the Local Reception Committee, but are not eligible to hold any other office, and they are not entitled to receive gratuitously the publications of the Association.

(*c*) Members may purchase from the Association (for the purpose of completing their sets) any of the Annual Reports of the Association, at a price to be fixed upon by the Council.

IV.—SUBSCRIPTIONS.

(*a*) The Annual Subscription for Members shall be One Pound, payable first at election, and thereafter on the First of July of each year. After the first session* intending Members shall be required to pay an Entrance Fee of One Pound in addition.

* The first session was held in Cape Town from 27th April to 2nd May, 1903.

(*b*) A Member may at any time become a Life Member by one payment of Ten Pounds, in lieu of future Annual Subscriptions, or in lieu of Entrance Fee and future Annual Subscriptions.

(*c*) The Subscription for Associates for a Session shall be Fifteen Shillings.

(*d*) The Council may authorise Local Committees to admit students as Associates at a reduced subscription on the special circumstances of each case being submitted.

V.—MEETINGS.

The Association shall meet in Session periodically for one week or longer. The place of meeting shall be appointed by the Council as far in advance as possible, and the arrangements for it shall be entrusted to the Local Committee, in conjunction with the Council.

VI.—COUNCIL.

(*a*) The Management of the affairs of the Association shall be entrusted to a Council, five to form a quorum.

(*b*) The Council shall consist of all past Presidents of the Association, past and present General Secretaries and Treasurers, and in addition representatives to be elected by each Centre, at a meeting to be held within one month prior to the Annual Meeting of the Association in the proportion of one representative for every 25 Members, and such others to be elected by the Members at the Annual Meeting of the Association, as shall give altogether one Member of Council to every 25 Members of the Association (excluding past Presidents and past and present General Secretaries and Treasurers).

(*c*) The Council so elected shall at once proceed to elect from its Members the President, four Vice-Presidents, two General Secretaries and one Treasurer. Assistant General Secretaries and local Honorary Treasurers may be elected at the Annual Meeting, or any Ordinary Meeting of the Council. The Council shall have the power to pay for the services of the Assistant General Secretaries, and for such clerical assistance as it may consider necessary.

(*d*) The Council shall have the power to add five Members (if necessary) to its number from among the Members of the Association resident in that Centre at which the next ensuing session is to be held.

(*e*) In the event of a vacancy occurring in the Council in the intervals between the Annual Sessions, the Council shall have the power to fill such vacancy.

(*f*) During any Session of the Association the Council shall meet, at least, twice.

(*g*) The Council shall have power to frame Bye-laws to facilitate the practical working of the Association, so long as these Bye-laws are not at variance with the Constitution.

VII.—MANAGING COMMITTEE OF COUNCIL.

In the intervals between the Sessions of the Association, its general affairs shall be managed by a Committee of Council consisting of President, General Treasurer, General Secretaries, and four other Members, elected annually by the Council. Three of the Committee shall form a quorum.

VIII.—LOCAL COMMITTEES.

In the intervals between the Sessions of the Association, its local affairs shall be managed by the Local Committees. This Committee shall consist of the Members of the Council resident in that Centre, with such other Members of the Association as the said Members of Council may elect.

IX.—RECEPTION COMMITTEE.

The Local Committee of the Centre at which the Session is to be held shall form a Reception Committee, to assist in making arrangements for the meeting, and for the reception and entertainment of the visitors.* This Committee shall have power to add to its number from among the Members and Associates of the Association.

X.—HEADQUARTERS.

The Headquarters of the Association shall be in Cape Town.

XI.—FINANCE.

(*a*) The Financial Year shall end on the 30th of June.

(*b*) All sums received for Life Subscriptions and for Entrance Fees shall be invested in the names of three Trustees appointed by the Council, and only the interest arising from such investment shall be applied to the uses of the Association.

(*c*) Subscriptions shall be collected by the Local Honorary Treasurer of each Centre, and by him forwarded to the General Treasurer, after deducting expenditure authorized by the Council.

(*d*) The Local Committees shall not have power to expend money without the authority of the Council, with the exception of the Local Committee of the Centre in which the next ensuing Session is to be held, which shall have the power to expend money collected, or otherwise obtained in that Centre. Such disbursements shall be audited, and the financial statement and the surplus funds forwarded to the General Treasurer at least half yearly.

(*e*) All cheques shall be signed either by the General Treasurer and a General Secretary, or by the Local Treasurer and Secretary of the Centre at which the next ensuing Session is to be held.

(*f*) Whenever the balance in the hands of the Treasurer shall exceed the sum requisite for the probable or current expenses of the Association, the Council shall invest the excess in the names of the Trustees.

(*g*) The whole of the accounts of the Association, *i.e.*, the local as well as the general accounts, shall be audited annually by an auditor appointed by the Council, and the balance-sheet shall be submitted to the Council at the first meeting thereafter, and be printed in the Annual Report of the Association.

XII.—GRANTS FOR RESEARCH.

(*a*) Grants may be made by the Association to Committees or to individuals for the promotion of Scientific research.

* For arrangements with regard to Papers to be read, see Section XIV.

(*b*) Committees and individuals to whom grants of money shall be entrusted are required to present to the following Meeting a report of the progress which has been made, together with a statement of the sums which have been expended. Any balance shall be returned to the General Treasurer. In each Committee the Secretary is the only person entitled to call on the Treasurer for such portions of the sums granted as may from time to time be required. In making grants of money to Committees or to individuals, the Association does not contemplate the payment of personal expenses to the Members, or to individuals.

XIII.—SECTIONS OF THE ASSOCIATION.

The Council shall have the power to constitute such sections of the Association as it may consider necessary. The following sections have been constituted:—

A. Astronomy.
Mathematics.
Meteorology.
Physics.
Geodesy.
Surveying.
Engineering.
Architecture.
Irrigation.

B. Chemistry.
Geography.
Geology.
Mineralogy.
Metallurgy.

C. Agriculture.
Forestry.
Bacteriology.
Botany.
Zoology.
Physiology.
Hygiene.
Sanitary Science.

D. Anthropology.
Ethnology.
Education.
History.
Mental Science.
Philology.
Political Economy.
Sociology.
Statistics.

XIV.—SECTIONAL COMMITTEES.

(*a*) The Presidents, Vice-Presidents and Secretaries of the several sections shall be chosen by the Council, after consultation with the Local Committee of the Centre at which the next ensuing Session of the Association is to be held.

(*b*) From the time of their election, which shall take place as

soon as possible after the Session of the Association, they shall form themselves into an organising Committee for the purpose of obtaining information upon Papers likely to be submitted to the Sections, and for the general furtherance of the work of the Sectional Committees. The Sectional Presidents of former years shall be *ex officio* Members of the Organising Committee.

(*c*) The Sectional Committees shall have power to add to their number from among the Members and Associates of the Association.

(*d*) The Committees of the several Sections shall determine the acceptance of Papers before the beginning of the Session, keeping the General Secretaries informed from time to time of their work. It is therefore desirable, in order to give an opportunity to the Committees of doing justice to the several communications, that each author should prepare an Abstract of his Paper, and he should send it, together with the original Paper, to the Secretary of the Section before which it is to be read, so that it may reach him at least a fortnight before the Session.

(*e*) Members may communicate to the Sections the Papers of non-members.

(*f*) The Author of any Paper is at liberty to reserve his right of property therein.

(*g*) The Sectional Committees shall meet not later than the first day of the Session in the Rooms of their respective Sections, and prepare the programme for their Sections and forward the same to the General Secretaries for publication.

(*h*) The Council cannot guarantee the insertion of any Report, Paper, or Abstract in the Annual Volume unless it be handed to the Secretary before the conclusion of the Session.

(*i*) The Sectional Committees shall report to the Council what Reports, Papers or Abstracts it is thought advisable to print, but the final decision shall rest with the Council.

XV.—RESEARCH COMMITTEES.

(*a*) In recommending the appointment of Research Committees, all members of such Committees shall be named, and one of them, who has notified his willingness to accept the office, shall be appointed to act as Secretary. The number of Members appointed to serve on a Research Committee shall be as small as is consistent with its efficient working. Individuals may be recommended to make reports.

(*b*) All recommendations adopted by Sectional Committees shall be forwarded without delay to the Council for consideration and decision.

XVI.—ALTERATION TO RULES.

Any proposed alteration of the Rules

a. Shall be intimated to the Council six months before the next Session of the Association.

b. Shall be duly considered by the Council, and, if approved, shall be communicated by Circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

XVII.—VOTING.

In Voting for Members of Council, or on questions connected with Alterations to Rules, absent Members may record their vote in writing.

RULES FOR THE AWARD OF MEDALS.

A. The South Africa Medal.

I.—Constitution of Committee.

(a) The Council of the South African Association for the Advancement of Science shall, annually and within three months after the close of the Annual Session, elect a Committee to be called "the South Africa Medal Committee" on which, as far as possible, every Section of the Association and each Colony of South Africa shall have fair representation.

(b) This Committee shall consist of a Chairman and not less than seven members, elected from amongst Council Members; and shall have power to add to its number additional members, not exceeding one-third of the original selected from members of the Association who are not on its Council.

(c) One-third of the members of this Committee shall retire annually by rotation, but shall be eligible for re-election.

II.—Duties.

(a) The duties of the Committee shall be to administer the Income of the Fund and to award the Medal, raised in commemoration of the visit of the British Association to South Africa in 1905, in accordance with the resolution of its Council.

(b) This resolution reads as follows:—

(1) That, in accordance with the wishes of subscribers, the South Africa Medal Fund be invested in the names of the Trustees appointed by the South African Association for the Advancement of Science;

(2) That the Dies for the Medal be transferred to the Association, to which, in its corporate capacity, the administration of the Fund and the award of the Medal shall be, and is hereby, entrusted, under the conditions specified in the Report of the Medal Committee.

(c) The terms of conveyance are as follows:—

(1) That the Fund be devoted to the preparation of a Die for a Medal, to be struck in Bronze, 2½ inches in diameter; and that the balance be invested and the annual income held in trust.

(2) That the Medal and income of the Fund be awarded by the South African Association for the Advancement of Science for achievement and promise in scientific research in South Africa.

(3) That, so far as circumstances admit, the award be made annually.

(d) The British Association has expressed a desire that the award shall be made only to those persons whose Scientific work is likely to be usefully continued by them in the future.

III.—Awards.

(a) Any individual engaged in Scientific research in South Africa shall be eligible to receive the award.

(b) The Medal and the available balance of one year's income from the Fund shall be awarded to one candidate only in each

year (save in the case of joint research); to any candidate once only; and to no member of the Medal Committee.

(c) Nominations for the recipient of the award may be made by any member of the South African Association for the Advancement of Science, and shall be submitted to the Medal Committee not later than six months after the close of the Annual Session.

(d) The Medal Committee shall recommend the recipient of the award to the Council, provided the recommendation is carried by the vote of at least a majority of three-fourths of its members, voting verbally or by letter, and submitted to the Council at least one month prior to the Annual Session for confirmation.

(e) The award shall be made by the full Council of the South African Association for the Advancement of Science after considering the recommendations of the Medal Committee, provided it is carried by the vote of a majority of its members, given in writing or verbally.

(f) The Council shall have the right to withhold the award in any year, and to devote the funds rendered available thereby, in a subsequent award or awards, provided the stipulation contained in the second term of conveyance of the British Association is adhered to.

(g) No alteration shall be made in these Rules except under the condition specified in Rule 16 of the Association's Constitution, reading:—

Any proposed alteration of the Rules

(a) Shall be intimated to the Council three months before the next Session of the Association.

(b) Shall be duly considered by the Council.

(c) And, if approved, shall be communicated by circular to the Members of the Association for their consideration,

(d) And dealt with at the said Session of the Association.

Should a member of the Medal Committee accept nomination for the Award he will forfeit his seat on the Committee.

B. The Goold-Adams Medals.

1. That the Medals be awarded on the joint results of the Matriculation and University Senior Certificate Examinations of the University of the Cape of Good Hope.

2. That one Medal be awarded to the student who has taken the highest place in each of the seven Science subjects: (1) Physics, (2) Chemistry, (3) Elementary Physical Science, (4) Botany, (5) Zoology, (6) Elementary Natural Science and (7) Mathematics, as set forth in the University Calendar as common to the University Matriculation Examination and the University Senior Certificate Examination.

3. That the standard of marks be not less than 65 per cent. of the maximum.

4. That the Medals be struck in bronze.

5. That the first awards be made on the results of the 1910 examinations.

Table showing the Places and Dates of Meeting of the South African Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Foundation.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
Sir DAVID GILL, K.C.B., LL.D., F.R.S., F.R.S.E. CAPE TOWN, April 27, 1903.	S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Sir Charles Metcalfe, Bart., M.I.C.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S.
Sir CHARLES METCALFE, Bart., M.I.C.E. JOHANNESBURG, April 4, 1904.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	T. Reunert, M.I.C.E., M.I.M.E.
THEODORE REUNERT, M.I.C.E., M.I.M.E. JOHANNESBURG, August 28, 1905.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	W. Cullen.
GARDNER F. WILLIAMS, M.A. KIMBERLEY, July 9, 1906.	J. Burtt-Davy, F.L.S., F.R.G.S. James Hyslop, D.S.O., M.B., C.M. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	W. M. Wallace, A.R.C.S., A.M.I.C.E.
JAMES HYSLOP, D.S.O., M.B., C.M. DURBAN, July 16, 1907.	J. Burtt-Davy, F.L.S., F.R.G.S. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S.	C. W. P. Douglas de Fenzi.
H.E. the Hon. Sir WALTER HELY-HUTCHINSON, G.C.M.G., LL.D. GRAHAMSTOWN, July 6, 1908.	Prof. J. C. Beattie, D.Sc., F.R.S.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S. Ernest Williams, A.M.I.C.E., M.I.M.M.	Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S. W. Hammond Tooke.
H.E. Sir HAMILTON GOOLD-ADAMS, G.C.M.G., C.B. BLOEMFONTEIN, September 27, 1909.	J. Burtt-Davy, F.L.S., F.R.G.S. Hugh Gunn, M.A. R. Marloth, M.A., Ph.D. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S.	Prof. G. Potts, M.Sc., Ph.D. A. Stead, B.Sc., F.C.S.
THOMAS MUIR, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. CAPE TOWN, October 31, 1910.	W. Cullen Hugh Gunn, M.A. Prof. P. D. Hahn, M.A., Ph.D. J. M. P. Muirhead, F.S.S., F.R.S.E.	C. F. Juritz, M.A., D.Sc., F.I.C.

Presidents and Secretaries of the Sections of the Association.

Date and Place.	Presidents.	Secretaries.
SECTION A.—ASTRONOMY, CHEMISTRY, MATHEMATICS, METEOROLOGY AND PHYSICS.		
1903. Cape Town ..	Prof. P. D. Hahn, M.A., Ph.D.	Prof. L. Crawford.
1904. Johannesburg*	J. R. Williams, M.I.M.M., M.Amer.I.M.E.	W. Cullen, R. T. A. Innes.
1906. Kimberley ..	J. R. Sutton, M.A.	W. Gasson, A. H. J. Bourne.
1907. Natal† ..	E. N. Neville, F.R.S., F.R.A.S., F.C.S.	D. P. Reid, G. S. Bishop.
1908. Grahamstown	A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.	D. Williams, G. S. Bishop.
ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND GEOGRAPHY.		
1909. Bloemfontein	Prof. W. A. D. Rudge, M.A.	H. B. Austin, F. Masey.
1910. Cape Town‖..	Prof. J. C. Beattie, D.Sc., F.R.S.E.	A. H. Reid, F. Flowers.
SECTION B.—ANTHROPOLOGY, ETHNOLOGY, BACTERIOLOGY, BOTANY, GEOGRAPHY, GEOLOGY, MINERALOGY AND ZOOLOGY.		
1903. Cape Town ..	R. Marloth, M.A., Ph.D.	Prof. A. Dendy.
1904. Johannesburg	G. S. Corstorphine, B.Sc., Ph.D., F.G.S.	Dr. W. C. C. Pakes, W. H. Jollyman.
1906, Kimberley ..	Thos. Quentrall, M.I.Mech.E., F.G.S.	C. E. Addams, H. Simpson.
CHEMISTRY, METALLURGY, MINERALOGY, GEOLOGY, ENGINEERING, MINING AND ARCHITECTURE.		
1907. Natal ..	C. W. Methven, M.I.C.E., F.R.S.E., F.R.I.B.A.	R. G. Kirkby, W. Paton.
1908. Grahamstown	Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.	Prof. G. E. Cory, R. W. Newman, J. Muller.
CHEMISTRY, BACTERIOLOGY, GEOLOGY, BOTANY, MINERALOGY, ZOOLOGY, AGRICULTURE, FORESTRY, SANITARY SCIENCE.		
1909. Bloemfontein	C. F. Juritz, M.A., D.Sc., F.I.C.	Dr. G. Potts, A. Stead.
CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY & GEOGRAPHY.		
1910. Cape Town ..	A. W. Rogers, M.A., Sc.D., F.G.S.	J. G. Rose, G. F. Ayers.
SECTION C.—AGRICULTURE, ARCHITECTURE, ENGINEERING, GEODESY, SURVEYING, AND SANITARY SCIENCE.		
1903. Cape Town ..	Sir Chas. Metcalfe, Bart., M.I.C.E.	A. H. Reid.
1904. Johannesburg‡	Lieut.-Col. Sir Percy Girouard, K.C.M.G., D.S.O.	G. S. Burt Andrews, E. J. Laschinger.
1906. Kimberley ..	S. J. Jennings, C.E., M.Amer.I.M.E., M.I.M.E.	D. W. Greatbatch, W. Newdigate.
BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE AND FORESTRY, PHYSIOLOGY, HYGIENE.		
1907. Natal ..	Lieut.-Colonel H. Watkins Pitchford, F.R.C.V.S.	W. A. Squire, A. M. Neilson, Dr. J. E. Duerden.
1908. Grahamstown	Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S.	Dr. J. Bruce Bays, W. Robertson, C. W. Mally, Dr. L. H. Gough.

* Metallurgy added in 1904.

† Geography and Geodesy transferred to Section A and Chemistry and Metallurgy to Section B, in 1907.

‖ Irrigation added in 1910 and Geography transferred to Section B.

‡ Forestry added in 1904.

Date and Place.	Presidents.	Secretaries.
1910. Cape Town*	Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S.	W. D. Severn, Dr. J. W. B. Gunning.
SECTION D.—ARCHÆOLOGY, EDUCATION, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.		
1903. Cape Town ..	Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	Prof. H. E. S. Fremantle.
1904. Johannesburg	(Sir Percy Fitzpatrick, M.L.A.), E. B. Sargant, M.A. (Acting).	Howard Pim, J. Robinson.
1906. Kimberley ..	A. H. Watkins, M.D., M.R.C.S.	E. C. Lardner-Burke, E. W. Mowbray.
EDUCATION, PHILOLOGY, PSYCHOLOGY, HISTORY, ARCHÆOLOGY; ECONOMICS AND STATISTICS, SOCIOLOGY, ANTHROPOLOGY AND ETHNOLOGY.		
1907. Natal ..	R. D. Clark, M.A.	R. A. Gowthorpe, A. S. Langley, E. A. Belcher.
EDUCATION, PHILOLOGY, PSYCHOLOGY, HISTORY & ARCHÆOLOGY.		
1908. Grahamstown	E. G. Gane, M.A.	Prof. W. A. Macfadyen, W. D. Neilson.
ECONOMICS AND STATISTICS, SOCIOLOGY, ANTHROPOLOGY AND ETHNOLOGY.		
1908. Grahamstown	W. Hammond Tooke.	Prof. A. S. Kidd.
ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.		
1909. Bloemfontein	Hugh Gunn, M.A.	G. C. Grant, Rev. W. A. Norton.
1910. Cape Town ..	Rev. W. Flint, D.D.	G. B. Kipps, W. E. C. Clarke.

EVENING DISCOURSES.

Date and Place.	Lecturer.	Subject of Discourse.
1903. Cape Town ..	Prof. W. S. Logeman, L.H.C., B.A.	The ruins of Persepolis and how the inscriptions were read.
1904. Johannesburg	H. S. Hele-Shaw, LL.D., F.R.S., M.I.C.E.	Road Locomotion — Present and Future.
1906. Kimberley ..	Prof. R. A. Lehfeldt, B.A., D.Sc.	The Electrical aspect of Chemistry.
	W. C. C. Pakes, L.R.C.P., M.R.C.S., D.P.H., F.I.C.	The immunisation against disease of micro-organic origin.
1907. Maritzburg ..	R. T. A. Innes, F.R.A.S.	Some recent problems in Astronomy.
Durban ..	Prof. R. B. Young, M.A., B.Sc., F.R.S.E., F.G.S.	The Heroic Age of South African Geology.
1908. Grahamstown	Prof. G. E. Cory, M.A.	The history of the Eastern Province.
	A. Theiler, C.M.G., M.D.	Tropical and sub-tropical diseases of South Africa: their causes and propagation.
1909. Bloemfontein	C. F. Juritz, M.A., D.Sc., F.I.C.	Celestial Chemistry.
	W. Cullen.	Explosives: their manufacture and use.
Maseru ..	R. T. A. Innes, F.R.A.S.	Astronomy.
1910. Cape Town ..	Prof. H. Bohle, M.I.E.E.	The conquest of the air.

* Sanitary Science added in 1910.

GENERAL MEETINGS AT CAPE TOWN.

On *Monday, October* 31, at 8.15 p.m. in the Engineering Laboratory Lecture Theatre of the South African College, Dr. Thomas Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E., took the chair as President and delivered an address, for which see page 1. A vote of thanks was accorded to the President by acclamation on the motion of the Hon. J. C. Smuts, B.A., LL.B., M.L.A., Minister of the Interior, seconded by Dr. J. Hyslop, D.S.O., M.B., C.M.

The President then presented the South Africa medal and grant to Prof. J. C. Beattie, D.Sc., F.R.S.E. For the proceedings see page xxvii. This was followed by a reception given by the local members of the Association and the Council of the South African College.

On *Wednesday, November* 2, at 8 p.m., Members of the Association visited the Royal Observatory.

On *Thursday, November* 3, at 9.30 a.m., the Eighth Annual General Meeting was held in the Teachers' Training Institute, for minutes of which see page xv.

At 8.15 p.m. in the Engineering Laboratory Lecture Theatre of the South African College, Prof. H. Bohle, M.V.D.E., M.I.E.E., delivered a discourse on "The Conquest of the Air," Mr. J. M. P. Muirhead, F.S.S., F.R.S.E., Vice-President, presiding.

On *Saturday, November* 5, at 7.45 p.m. Members attended a reception given by His Worship the Mayor of Cape Town, Sir Frederick Smith, Kt., J.P., in honour of T.R.H. the Duke and Duchess of Connaught and Strathearn, and Princess Patricia.

OFFICERS OF LOCAL AND SECTIONAL COMMITTEES, CAPE TOWN, 1910.

LOCAL COMMITTEE.

Chairman, T. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.; *Local Secretary*, C. F. Juritz, M.A., D.Sc., F.I.C.; *Assistant Secretary*, E. Hope Jones; G. F. Britten, B.A. (*Acting*); Prof. H. Bohle, M.I.E.E., Prof. L. Crawford, M.A., D.Sc., F.R.S.E., W. J. Dodds, M.D., D.Sc., Rev. W. Flint, D.D., Prof. J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S., C.M.Z.S., Prof. P. D. Hahn, M.A., Ph.D., C. P. Lounsbury, B.Sc., F.E.S., R. Marloth, M.A., Ph.D., J. M. P. Muirhead, F.S.S., F.R.S.E, Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S., A. Walsh.

RECEPTION COMMITTEE.

Chairman, His Worship the Mayor of Cape Town (Sir F. W. Smith, Kt., J.P.); *Hon. Secretaries*, J. G. Rose, F.C.S., A. S. Giles, M.I.E.E.; W. Adamson, F.R.I.B.A., M. Alexander, M.A., LL.B., G. T. Amphlett, A. J. Anderson, M.A., M.B., M.R.C.S., D.P.H., His Grace the Archbishop of Capetown, E. W. Attridge, M.I.San.E., Prof. F. W. Aulesbrook, B.A., T. Ball, C.M.G., Rev. R. Balmforth, Sir P. C. van B. Stewart-Bam Kt., C. Procter Banham, M.I.E.E., M.I.Mech.E., W. Baxter M.A., W. Duncan Baxter, Prof. J. C. Beattie, D.Sc., F.R.S.E., Rev A. P. Bender, M.A., H. Bolus, D.Sc., F.L.S., Prof. A. Brown, M.A., B.Sc., F.R.S.E., Hon. Justice Sir E. J. Buchanan, Kt., LL.D., W. T. Buissinné, Hon. H. Burton, K.C., B.A., LL.B., J. D. Cartwright, E. J. Cattell, Miss A. H. Chambers, Prof. J. Clark, M.A., LL.D., H. Cloete, C.M.G., J. E. P. Close, B.A., The Coadjutor Bishop of Capetown, A. H. Cornish-Bowden, S. Cowper, C.M.G., W. H. Cox, D. Craib, M.A., D. C. Crawford, M.A., B.Sc., G. Cresswell Clark, The Dean of Cape Town, J. Denham, M.I.E.E., Hon. N. F. de Waal, Prof. P. J. du Toit, B.A., Ph.D., Prof. J. Edgar, M.A., C. J. Edwards, H. H. Elliott, A.M.I.C.E., Hon. Sir P. H. Faure, K.C.M.G,, J. E. Foakes, Miss M. E. Freeman, H. E. S. Fremantle, M.A., F.S.S., E. B. Fuller, M.B., F. G. Gardiner, B.A., J. Garlick, Hon. D. P. de V. Graaff, Sir J. J. Graham, K.C.M.G., G. A. L. Green, J. A. Greer, LL.D., Rev. Dr. B. J. Haarhoff, J. K. E. Halm, Ph.D., A. Handel Hamer, H. Hands, R. H. Heward, J. Hewat, M.D., C.M., Prof. R. F. A. Hoernlé, M.A., B.Sc., Hon. Justice W. M. Hopley, LL.B., S. S. Hough, M.A., F.R.S., J. Noble Jack, J. W. Jagger, F.S.S., N. Janisch, F.S.S., Rev. Canon W. O. Jenkins, M.A., D.D., Hon. Sir H. H. Juta, Kt., K.C., B.A., LL.B., F. E. Kanthack, A.M.I.C.E., Prof. T. P. Kent, M.A., E. F. Kilpin, C.M.G., Rev. F. C. Kolbe, B.A., D.D., Prof. C. E. Lewis, M.A., E. T. Littlewood, M.A., B.Sc., J. B. Lindley, C.M.G., M.A., LL.B., Prof. W. S. Logeman, B.A., L.H.C., B. K. Long, B.A., LL.B., W. F. Long, J. Lunt, D.Sc., F.I.C., F.R.A.S., Hon. Justice C. G. Maasdorp, M.A., L. MacLean, L. Mansergh, I.S.O., C. B. Martin, The Mayors of Sea Point, Woodstock, Mowbray, Rondebosch, Claremont, Wynberg,

Muizenberg, Simons Town, and Maitland, Prof. J. Martin, M.A., D. E. McConnell, T. S. McEwen, A.M.I.C.E., Rev. J. J. McClure, D.D., R. W. Menmuir, A.M.I.C.E., W. E. Moore, H. A. Moffat, B.A., F.R.C.S., L.R.C.P., J. T. Molteno, B.A., LL.B., Prof. J. T. Morrison, M.A., B.Sc., F.R.S.E., Miss E. Morton, L.L.A., C. Murray, M.A., C. F. K. Murray, M.D., C.M., F.R.C.S.I., F. Murray, M.B., C.M., Prof. R. D. Nauta, E. Noaks, M.A., H. M. E. Orpen, M. H. Park, M.A., LL.D., J. Parker, F.R.I.B.A., A. J. Parsons, J. Petersen, M.B., C.M., A. H. Petersen, M.D., L.R.C.P., L.F.P.S., R. T. Pett, Rev. A. Pitt, K. B. Quinan, A. H. Reid, F.R.I.B.A., F. W. Reitz, Prof. W. Ritchie, M.A., G. W. Robertson, M.R.C.S., L.R.C.P., Rev. G. W. Rogers, A. W. Rogers, M.A., Sc.D., F.G.S., Hon. Justice Sir J. Rose-Innes, K.C.M.G., B.A., LL.B., Rev. J. M. Russell, M.A., B.D., W. A. Russell, M.A., Hon. W. P. Schreiner, C.M.G., K.C., M.A., LL.M., Hon. Justice M. W. Searle, K.C., B.A., LL.B., J. D. Shannon, H. B. Shawe, Prof. A. E. Snape, M.Sc., A.M.I.C.E., M.R.San.I., Rt. Hon. Sir. J. G. Sprigg, G.C.M.G., T. W. Stainthorpe, A.M.I.C.E., Sir. E. S. Stevenson, Kt., M.D., L.R.C.P., F.R.C.S.E., C. M. Stewart, B.Sc., T. Stewart, M.I.C.E., F.G.S., C. F. W. Struben, M.A., W. H. Struben, Prof. R. N. D. Sutton, B.A., E. R. Syfret, S. B. Syfret, M.B., B.S., Hon. T. N. G. te Water, M.D., C.M., W. Thomson, M.A., B.Sc., LL.D., F.R.S.E., Sir W. Thorne, Kt., B. Upington, V. van der Byl, C. H. van Zyl, Prof. G. W. Vipan, M.A., J. P. L. Volsteedt, B.A., Rev. Prof. T. Walker, M.A.,, LL.D., Litt. D., Rev. S. R. Welch, Ph.D., D.D., W. White Phillips, J. R. Whitton, L. Wiener, G. S. Withinshaw, T. Young, M.A.

SECTIONAL COMMITTEES.

Section A. — ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND IRRIGATION.

President, Prof. J. C. Beattie, D.Sc., F.R.S.E. ; *Vice-Presidents :* J. R. Sutton, M.A., Sc.D., A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E., E. Nevill, F.R.S., Sir Charles Metcalfe, Bart., M.I.C.E., Prof. W. A. D. Rudge, M.A., (*ex-officio*) Prof. H. Bohle, Prof. L. Crawford, M.A., D.Sc., F.R.S.E., G. W. Herdman, M.A., M.I.C.E., S. S. Hough, M.A., F.R.S., R. T. A. Innes, F.R.A.S., F. E. Kanthack, A.M.I.C.E., Prof. R. A. Lehfeldt, B.A., D.Sc., J. Lyle, M.A., Prof. John Orr, B.Sc., M.I.C.E., Theo. Reunert, M.I.C.E.; *Hon. Secretaries*: A. H. Reid, F.R.I.B.A., F.R.San.I. (*Recorder*); Frank Flowers, F.R.G.S., F.R.A.S.

Section B. — CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.

President, A. W. Rogers, M.A., Sc.D., F.G.S. ; *Vice-Presidents :* Prof. P. D. Hahn, Ph.D., M.A., G. S. Corstorphine, B.Sc., Ph.D., F.G.S., Prof. E. H. L. Schwarz, A.R.C.S., F.G.S., C. F. Juritz, M.A., D.Sc., F.I.C., (*ex officio*) Wm. Cullen, W. A. Caldecott, B.A., D.Sc., F.C.S., A. von Dessauer, M.E., J. Moir, M.A., D.Sc., F.C.S., Prof. G. H. Stanley, A.R.S.M., M.I.M.M., Albert Walsh, Prof. J. A. Wilkinson, M.A., F.C.S.; *Hon. Secretaries*: J. G. Rose, F.C.S. (*Recorder*); G. F. Ayers.

SECTION C.—BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE, FORESTRY, PHYSIOLOGY, HYGIENE AND SANITARY SCIENCE.

President, Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S.; *Vice-Presidents*: R. Marloth, M.A., Ph.D., Lt.-Col. H. Watkins-Pitchford, F.R.C.V.S., S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S., (*ex officio*) A. Jasper Anderson, M.A., M.B., D.P.H., M.R.C.S., Harry Bolus, D.Sc., F.L.S., J. Burtt-Davy, F.L.S., F.R.G.S., Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S., Prof. J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S., C. P. Lounsbury, B.Sc., F.E.S., W. J. Palmer, B.Sc., I. B. Pole-Evans, B.Sc., Prof. G. Potts, M.Sc., Ph.D., F. B. Smith, Arnold Theiler, C.M.G., M.D., R. W. Thornton, W. T. Saxton, M.A., F.L.S.; *Hon. Secretaries*: W. D. Severn, A.R.C.S., F.C.S., (*Recorder*); Dr. J. W. B. Gunning.

SECTION D.—ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

President, Rev. W. Flint, D.D.; *Vice-Presidents*: Dr. A. H. Watkins, M.R.C.S., E. G. Gane, M.A., W. Hammond Tooke, Hugh Gunn, M.A., (*ex officio*) J. E. Adamson, J. A. Foote, F.G.S., F.E.I.S., H. E. S. Fremantle, M.A., F.S.S., Rev. E. Jacottet, Rev. H. A. Junod, Prof. W. S. Logeman, B.A., L.H.C., T. W. Lowden, J. M. P. Muirhead, F.R.S.E., F.S.S., Maitland H. Park, M.A., LL.D., Louis Peringuey, D.Sc., F.E.S., F.Z.S., J. R. Whitton, W. Baxter, M.A., E. T. Littlewood, M.A., B.Sc., T. Young, M.A.; *Hon. Secretaries*: G. B. Kipps, F.R.G.S., (*Recorder*); W. E. C. Clarke, M.A.

PROCEEDINGS OF THE EIGHTH ANNUAL MEETING OF MEMBERS

(Held in the Teachers' Training Institute, Cape Town, on Thursday, November 4, 1910.)

PRESENT: Dr. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. (President) in the chair, and Messrs. C. D. H. Braine, A. K. Haagner, W. P. Cohen, Rev. Dr. Flint, Rev. R. Balmforth, Prof. L. Crawford, Prof. J. C. Beattie, Dr. A. McKenzie, Dr. D. Traill, C. J. Edwards, W. T. Saxton, J. Leighton, F. Flowers, M. H. Biebuyck, Prof. J. D. F. Gilchrist, A. H. Reid, R. W. Menmuir, A. Heymann, Dr. J. Moir, A. Walsh, W. Cullen, Prof. H. H. W. Pearson, J. Burtt-Davy, Rev. Dr. Welch, Dr. H. A. Spencer, Miss Wilman; Mr. R. T. A. Innes, and Dr. C. F. Juritz (Hon. General Secretaries) and Mr. G. F. Britten (Acting Assistant General Secretary).

MINUTES.—The Minutes of the Annual General Meeting held on the 3rd September, 1909, printed in the Report of the Bloemfontein Meeting, were confirmed.

ANNNUAL REPORT OF COUNCIL.—The Annual Report of the Council on the work of the past year (see p. xviii), which had been suspended in the Reception Room for the last three days, was taken as read, and adopted.

REPORT OF THE HON. TREASURER AND STATEMENT OF ACCOUNTS FOR 1909-1910.—These were also taken as read and adopted, as they had been exhibited in the Reception Room for the information of members for three days (see p. xxi).

SOUTH AFRICA MEDAL COMMITTEE.—It was resolved that Dr. Potts, Prof. Beattie, Dr. Crawford, and Dr. J. R. Sutton be elected members of this Committee until 1913, in the place of Rev. Dr. Flint, Dr. A. H. Watkins, Dr. Crawford and Mr. Lyle. The Committee now consists of the following members: Mr. S. S. Hough, Dr. S. Schönland, Mr. T. Reunert, and Dr. G. S. Corstophine, who retire in 1911; Dr. C. F. Juritz, Mr. W. Cullen, Dr. A. Theiler, and Mr. E. Nevill, who retire in 1912; and Dr. Potts, Prof. Beattie, Prof. Crawford and Dr. Sutton, who retire in 1913.

RECOMMENDATIONS FROM WITWATERSRAND MEMBERS OF COUNCIL.—Mr. Cullen moved that it be a recommendation to the Council from the General Meeting to take into consideration the grant of some remuneration to the Editor of the Journal. The motion was seconded by Mr. Burtt-Davy and agreed to.

Mr. Cullen also moved that it is desirable that the sale price of the Journal be reduced. The motion was seconded by Dr. Moir and declared lost.

MEETING IN 1911.—It was resolved that it be left to the incoming Council to make arrangements for the 1911 Annual Session of the Association.

AMENDMENT OF THE CONSTITUTION.—It was resolved that the incoming Council be instructed to appoint a special committee for the purpose of taking into consideration the various amendments to the Constitution of the Association that had been proposed, and that the Council report on the matter in time for considering the matter at the next Annual Meeting, the present Constitution meanwhile to remain in operation.

ELECTION OF COUNCIL FOR 1910-1911.—The following were elected as Members of Council for 1910-1911:—

I. TRANSVAAL.—*Witwatersrand*: Dr. J. Moir, F.C.S., Mr. F. Flowers, F.R.A.S., Mr. J. A. Foote, F.G.S., Professor G. H. Stanley, A.R.S.M., Mr. J. A. Vaughan, Professor J. Orr, B.Sc., A.M.I.C.E., Mr. A. Heymann. *Pretoria*: Mr. G. W. Herdman, M.A., M.I.C.E., Mr. J. Burtt-Davy, F.L.S., Dr. A. Theiler, C.M.G. *Middelburg*: Dr. H. A. Spencer. II. CAPE PROVINCE.—*Cape Peninsula*: Prof. J. C. Beattie, D. Sc., F.R.S.E., Prof. L. Crawford, M.A., D.Sc., F.R.S.E., Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S., Rev. W. Flint, D.D., Mr. A. Walsh, Mr. J. M. P. Muirhead, F.S.S., F.R.S.E., and Mr. A. H. Reid, F.R.I.B.A. *Grahamstown*: Prof. E. H. L. Schwarz, A.R.C.S., F.G.S. *East London and King William's Town*: Dr. G. Rattray, M.A., F.R.G.S. III. NATAL.—*Pietermaritzburg*: Dr. E. Warren. *Durban*: Dr. A. MacKenzie. IV. ORANGE FREE STATE AND BASUTOLAND.—*Bloemfontein*: Prof. W. A. D. Rudge, M.A., and Mr. A. Stead, B.Sc., F.C.S. *Basutoland*: Rev. E. Jacottet. V. RHODESIA: Mr. G. N. Blackshaw, B.Sc., F.C.S. VI. MOZAMBIQUE: Mr. C. W. Howard, B.A., F.E.S.

The following are members of Council, *ex-officio*:--*Past Presidents:* Sir David Gill, Sir Chas. Metcalfe, Mr. T. Reunert, Dr. Gardner F. Williams, Dr. J. Hyslop, Rt. Hon. Sir Walter Hely-Hutchinson, Sir Hamilton Goold-Adams, Dr. T. Muir.

Past Hon. General Secretaries: Mr. W. Cullen, Dr. J. D. F. Gilchrist, Mr. R. T. A. Innes, and Dr. C. F. Juritz.

Past Hon. General Treasurers: Mr. Howard Pim, Mr. W. D. Morton, Dr. J. McCrae, and Dr. R. A. Lehfeldt.

General Business. — The following was proposed by Prof. Pearson as an unopposed motion, seconded by Mr. W. Cullen, and carried: The members of the South African Association for the Advancement of Science assembled in Annual Session desire to record their opinion that in view of the recent discoveries by Russell and Hutchinson of certain important factors controlling soil fertility, it is of the greatest importance that, in the organisation of the Union Department of Agriculture, a strong Bureau of soil-surveys be established.

Mr. J. Burtt-Davy moved as an unopposed motion, seconded by Mr. Cullen, and it was carried, that the members of this Association desire further to record their opinion that the establishment of a National Botanic Garden, Herbarium, Museum, and Research Laboratories is urgently required.

The Council was instructed to lay these resolutions before the Minister of Agriculture at an early date.

Votes of Thanks.—The following votes of thanks, submitted by Prof. Crawford, were carried by acclamation:—

> To His Worship the Mayor of Cape Town; to the Education Department, the Council of the South African College, and the University of the Cape of Good Hope, for the use of their respective buildings; to the Admiral Commanding the Cape Station, the Astronomer Royal, and the President of the South African Medical Congress for invitations kindly extended; to Miss Juritz and the other ladies who gave their aid in connection with the reception at the South African College; to the South African Railway Administrations and the Union-Castle Mail Steamship Company for travelling facilities granted; to Messrs. Heynes, Mathew and Co. for their exhibit of scientific apparatus and their generous and gratuitous preparation of lantern slides for members who needed them to illustrate their papers; to the Cape Peninsula Publicity Association for a large quantity of descriptive handbooks supplied; to the respective Secretaries and members of the Reception Committee, the Hospitality Committee, the Excursions Committee, the Press and Publications Committee, and the several Sectional Committees; to the Metropolitan and Rondebosch Golf Clubs, the City Club, the Junior Civil Service Club, and the German Club for the privilege of Honorary Membership granted to visiting Members of the Association during the Session; to all members who have so kindly offered hospitality to visitors, or who have contributed towards the local expenses; to the Honorary Auditors; and to the Press for publicity given to the Association's proceedings.

The meeting then closed.

REPORT OF THE COUNCIL FOR THE YEAR ENDED 30TH JUNE, 1910.

1. Your Council desires to submit the following report upon the work of the Association for the twelve months, 1st July, 1909, to 30th June, 1910.

2. HIS MAJESTY THE KING.—As foreshadowed in the last Annual Report, your Council, shortly after taking office, approached His Majesty King George V., then Prince of Wales, with a view to his accepting the office of Honorary President of this Association, in view of his anticipated visit to South Africa. The greatly-deplored demise of His late Majesty King Edward VII. prevented the hoped-for visit from being carried into effect, but the request of your Council had already been acceded to, and His present Majesty accordingly remains Honorary President of the Association.

3. MEMBERSHIP.—At the close of the year under report there were 693 members on the Association's books. They were distributed as follows:—

Transvaal	295
Cape	236
Orange Free State	53
Natal	41
Rhodesia	15
Basutoland	10
Mozambique	5
Swaziland	1
German South West Africa	1
Resident abroad	21
Residence unknown	15
	693

Of these, 32 were Life Members. Eighty-eight members, who were two years in arrear with their subscriptions, were retained on the list in pursuance of a resolution of Council to allow a year's grace to members who became liable to removal from the register by reason of being more than one year in arrear.

4. CENTRE OF ADMINISTRATION.—Consequent upon the resolutions passed at the Bloemfontein meeting a year ago, the Johannesburg office has been closed and the administrative work of the Association has been centred in a single office at Cape Town since the commencement of the present calendar year. Notwithstanding an increased expenditure for purposes of publication, the economy effected by the administrative change has been sufficient, together with the successful collection of arrear subscriptions, and in spite of prevailing commercial depression, to place the Association in a better financial position than hitherto.

5. RESIGNATION OF ASSISTANT GENERAL SECRETARY.—On account of his transference to Pretoria, Mr. E. Hope Jones, who has held the office of Assistant General Secretary in Cape Town ever since the establishment of the Association, has been

compelled to tender his resignation. Your Council highly appreciates the devotion to the interests of the Association which has invariably characterised Mr. Jones' services, and keenly regrets the necessity of accepting his resignation.

6. Report of the Bloemfontein Meeting, 1909.—At the last Annual Meeting a motion was submitted by Professor Potts to the effect "that steps be taken to render more money available for purposes of publication." That motion was withdrawn on the understanding that it would be acted upon by Council, chiefly in the direction of publishing the proceedings of the Annual Session in the form of a monthly journal, capable of being bound, at the close of the year, into a volume uniform with the Annual Reports previously issued by the Association. When the year now under report closed, eight monthly issues of that journal had appeared, at a cost of about £210, and it was anticipated that when complete the volume would be almost equal in size to the Report of the Johannesburg Meeting in 1904.

7. Grants for Research.—No further applications for grants have been considered, nor has your Council received any further reports from Dr. A. W. Roberts, Dr. J. D. F. Gilchrist, and Dr. J. Stuart Thomson, to whom grants had previously been issued. Dr. Roberts will, however, it is understood, read a paper on the progress of his work on variable stars during the present Session.

8. South Africa Medal Fund.—On the recommendation of the South Africa Medal Committee, consisting of Rev. Dr. Flint, Prof. L. Crawford, Dr. A. H. Watkins, Mr. J. Lyle, M.A., Mr. S. S. Hough, F.R.S., Prof. S. Schönland, Mr. T. Reunert, Dr. G. S. Corstorphine, Dr. C. F. Juritz, Mr. W. Cullen, Dr. Theiler, and Mr. E. N. Nevill, F.R.S., the third award of the South Africa Medal and a grant of £50 has been made to Professor J. C. Beattie, D.Sc., F.R.S.E.

The Medal Fund (exclusive of the above £50) now amounts to £1,402, of which £1,376 is invested in a Cape Treasury Bill, drawing interest at the rate of four per cent. per annum.

Drs. Flint, Crawford, and Watkins, and Mr. Lyle retire by rotation from the Medal Committee at this meeting, and it will devolve upon you to appoint their successors. Owing to the difficulty experienced in the past in obtaining the requisite number of votes in connection with the award, your Council recommends that only those should be appointed members of the Medal Committee who are not likely, through absence from South Africa, to be unable to record their votes when the time for awarding the 1911 medal arrives, and with this object in view certain amendments to the medal rules have been drafted and will be submitted for your consideration at this meeting.

9. Constitution.—The practical difficulty of adhering in all points to the provisions of the Constitution, as at present laid down, was borne in upon your Council within a short time of taking office: a Committee, consisting of Mr. Muirhead, Rev. Dr. Flint, Mr. Cullen, Dr. Moir, Mr. Innes, and Dr. Juritz was therefore appointed to consider the matter. This Com-

mittee has submitted an amended Constitution, which, together with some further amendments, subsequently proposed, will be laid before you for consideration.

10. LECTURES.—The South African Lectures for 1910 have been delivered by Mr. Henry Balfour, M.A., Curator of the Pitt Rivers Museum. The subject of the lectures was Anthropology, and the following aspects were variously dealt with by the lecturer:—

1. Anthropology as a branch of Science, and as a subject of Academic study;
2. Ethnology and Archæology;
3. Evolution in the Arts and Industries of man;
4. Some African problems, ethnological and archæological;
5. The influence of environment upon primitive people;
6. African musical instruments, their development and ethnological bearing;
7. The beginnings of realistic and decorative art.

The South African towns visited by Mr. Balfour in the course of his lecturing tour were: Cape Town, Port Elizabeth, Grahamstown, East London, Durban, Pietermaritzburg, Harrismith, Bloemfontein, Kimberley, Johannesburg, Pretoria, Modderfontein, and Krugersdorp.

11. STANDING COMMITTEES.—The Educational, Anthropological, and Forestry Standing Committees are still in existence, but for at least two years no reports have been received from them. The following reference in last year's report continues to hold good:—"An amount of £20 has been received from the Transvaal Government as a grant towards the objects of the Anthropological Committee, which has not yet been expended, the work of this Committee being held in abeyance pending the result of the representations which were being made to the Transvaal Government."

12. GOOLD-ADAMS MEDALS.—A die for the medals presented by Sir Hamilton Goold-Adams, G.C.M.G., late Governor of the Orange River Colony, and President of the Bloemfontein Meeting of this Association, has now been completed, and your Council has adopted the following rules with reference to the award of the medals:—

1. That the medals be awarded on the joint results of the Matriculation and University Senior Certificate Examinations of the University of the Cape of Good Hope.
2. That one medal be awarded to the student who has taken the highest place in each of the seven Science subjects: (1) Physics, (2) Chemistry, (3) Elementary Physical Science, (4) Botany, (5) Zoology, (6) Elementary Natural Science, and (7) Mathematics, as set forth in the University Calendar as common to the University Matriculation Examination and the University Senior Certificate Examination.
3. That the standard of marks be not less than 65 per cent. of the maximum.
4. That the medals be struck in bronze.

5. That the first awards be made on the result of the 1910 examinations.

13. MEETING IN 1911.—The arrangements for the 1911 Annual Session are not yet complete, and it is recommended that the incoming Council be given full powers to deal with the matter as may seem fit.

14. THE NEW COUNCIL.—It is recommended that the distribution of Members of Council for the ensuing year amongst the various centres be as follows:—

Transvaal:	
Witwatersrand	10
Pretoria	3
Potchefstroom	1
Orange Free State:	
Bloemfontein	3
Cape:	
Cape Peninsula	7
Grahamstown	2
East London and King William's Town	1
Kimberley	1
Port Elizabeth	1
Natal:	
Pietermaritzburg	1
Durban	1
Rhodesia	1
Basutoland	1
Lourenço Marques and Beira	1

15. TREASURER'S STATEMENTS.—The Treasurer's Report for the year is submitted herewith, together with the Statement of Revenue and Expenditure, and the Balance Sheet of the Association.

The Treasurer's Revenue Account shows that the Association has a surplus for the year of £234.

REPORT OF THE HONORARY TREASURER FOR THE YEAR ENDED 30TH JUNE, 1910.

I beg to submit the following report and accounts for the financial year ended June 30th, 1910.

The membership is nominally about the same as last year, but the Council has been more strict in striking off the names of those who neglect to pay subscriptions, and has been more successful than usual in collecting arrears; the real position of the Association is, therefore, slightly better.

The Revenue Account shows a balance of £233; if the arrear subscriptions (£259) were deducted from this, a slight loss would be shown. But though the actual collection of arrears was unusually high, some is always to be expected; it may, therefore, be said that the Association is paying its way, and making a small profit. This, however, has only been accomplished by suspending grants for research.

The Endowment Fund should stand at £1,091. On account of the loan authorised last year and suspension of investment of entrance and life member fees, the invested funds actually stand at £688. The difference, £403, is to be regarded as a charge against the balance of £501 13s. 8d. There were no outstanding debts at the date of the balance sheet. It appears therefore that the Association could afford to restore the greater part of the sum temporarily withdrawn from investment, and still leave a working balance. This should be done.

The South Africa Medal Fund has yielded an income of £75 17s. 10d.; this has admitted of paying a grant of £50 to the recipient of the Medal and covering the expense of Medals.

The administration having now been centralised at Cape Town, it is to be expected that expenses will be reduced, so that if the coming meeting there leads to a sensible increase in membership, the Association may again find itself in a position to promote the cause of Science in other ways than those to which it has been restricted by the financial depression of recent years.

R. A. LEHFELDT,
Hon. General Treasurer.

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

REVENUE ACCOUNT FOR THE YEAR ENDED 30TH JUNE, 1910.

Expenditure.

To Charges (including postages and sundries) ..				£50	4	10
,, Printing and Stationery ..				29	18	11
,, Salaries ..				182	4	7
,, Depreciation on furniture ..				2	10	0
,, Expenses—Bloemfontein Meeting ..				59	18	6
,, Branch expenses ..				4	12	1
,, Journal Account: Cost of printing, postages, etc. ..	£263	19	10			
Less Sales and Advertisements ..	7	7	6			
				256	12	4
,, Balance, being excess of Revenue over Expenditure ..				233	13	5
				£819	14	8

Revenue.

By Subscriptions, 1909-10 ..	£506	0	0
,, ,, arrears ..	259	0	0
,, ,, Associates Bloemfontein Meeting	26	5	0
,, Interest on Fixed Deposit, £688, to 18th May, 1910 ..	24	1	8
,, Sale of Proceedings ..	4	8	0
	£819	14	8

BALANCE SHEET AT 30TH JUNE, 1910.

Liabilities.

To Subscriptions paid in advance			£13 2 0
,, South Africa Medal Fund			1,451 17 10
,, Endowment Fund Account: Balance 31.6.09 ..			996 0 0
,, Received to 30.6.10, Entrance Fees			65 0 0
,, Life Membership subscriptions			30 0 0
,, Anthropological Standing Committee			20 0 0
,, Revenue Account: Balance from Revenue Account above ..		£233 13 5	
Less Dr. Balance at 30.6.09	£147 5 3		
Plus amount S.A. Medal Fund Interest previously written off erroneously ..	5 16 6		
		153 1 9	
			80 11 8
			£2,656 11 6

Assets.

By S.A. Medal Fund: Trustees' Account		£1,376 0 0
,, ,, ,, ,, Interest		75 17 10
,, Invested Funds: Amount on Fixed Deposit	£988 0 0	
Less amount loaned to Current Account	300 0 0	
		688 0 0
,, Furniture		15 0 0
,, Cash at Bank		501 13 8
		£2,656 11 6

SOUTH AFRICAN ASSOCIATION FOR ADVANCEMENT OF SCIENCE (JOHANNESBURG).

STATEMENT OF LEDGER BALANCES ON CLOSING OF JOHANNESBURG OFFICE, 1910.

Ledger folio.		£ s. d.	£ s. d.
5	Interest on Fixed Deposit		12 0 10
10	Associate Fees: Bloemfontein		25 10 0
4/21	Entrance Fees		47 0 0
27	Subscriptions, 1907-08		17 0 0
30/1 28	,, 1908-09		162 0 0
32/3	,, 1909-10		347 0 0
36	,, 1910-11		1 2 0
56	,, Life Members		20 0 0
57	Loan Account (Deduct from Fixed Deposit in Balance Sheet)		300 0 0
60	Anthropological Standing Committee ..		20 0 0
61	S.A. Medal Fund, Interest Account ..	5 16 6	
63	Fixed Deposit Account (Invested Funds) ..	988 0 0	
68	Proceedings Account (Volumes sold) ..		2 16 0
74	Furniture Account	17 10 0	
75	Revenue and Expenditure Account.. ..	147 5 3	
78	Endowment Fund Account		996 0 0
86	Printing and Stationery	15 4 6	
89	Salaries Account	87 4 7	
96	Bloemfontein Meeting Expenses	59 18 6	
99	Branch Expenses	4 12 1	
101	Charges Account	29 10 2	
108	Journal Account	3 13 1	
166	Cape Colony and Rhodesia Account ..	591 14 2	
		£1,950 8 10	£1,950 8 10

R. A. LEHFELDT, FRED ROWLAND, F.C.I.S.
Treasurer.

June 30th, 1910.

I have examined the Books, Vouchers and Accounts of the Association kept at Johannesburg for the period from 1st July, 1909, to date of closing the accounts, including the Revenue and Expenditure Account of the Cape Colony and Rhodesian Section for the six months ending 31st December, 1909, the latter being unaudited. Subject to the foregoing, I testify that the above statement of ledger balances is correct.

MICHAEL B. GARDNER, Inc. Acct.,
Hon. Auditor.

Johannesburg, 29th June, 1910.

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

STATEMENT OF RECEIPTS AND EXPENDITURE FOR THE PERIOD 1ST JULY, 1909, TO 30TH JUNE, 1910, PREPARED FROM BOOKS KEPT AT CAPETOWN.

Receipts.	£	s.	d.
To Balance on 1.7.1909	£67	12	3
,, Entrance Fees	24	0	0
,, Subscriptions, Life Members	20	0	0
,, ,, Annual Members, 1907-08 ..	18	0	0
,, ,, ,, 1908-09 ..	101	0	0
,, ,, ,, 1909-10 ..	240	0	0
,, ,, ,, 1910-11 ..	13	0	0
,, ,, Associates, 1909 Meeting.. ..	3	0	0
,, Interest derived from Invested Funds, £688 at $3\frac{1}{2}$% from 19.5.09 to 18.5.10	24	1	8
,, Interest received from Trustees of South Africa Medal Fund	65	3	0
,, Remittance from Treasurer, Johannesburg ..	446	14	0
,, Sales of copies of "Science in South Africa" ..	2	17	0
,, ,, of Monthly Journal	3	6	0
,, Sale of reprints from Monthly Journal	2	1	6
,, Advertisements in Monthly Journal	2	0	0
	£1,032	15	5

Expenditure.	£	s.	d.
By Salary, Asst. General Secretary, 1.7.09–30.6.10..	£87	4	7
,, ,, Clerk-typist, 1.10.09–30.6.10	45	0	0
,, Postage—general	20	2	3
,, Telegrams	1	3	7
,, Printing, Typing, Stationery & Office requisites	26	14	5
,, Electric Light	6	0	0
,, ,, Deposit as security	1	0	0
,, Rent of P.O. Box 1497, Cape Town	1	0	0
,, Registration of telegraphic address	1	1	0
,, Grant awarded to Dr. Theiler with S.A. Medal ..	50	0	0
,, Engraving of S.A. Medal	0	3	6
,, Repayment to Trustees of S.A. Medal Fund of interest received in excess of Grants made ..	20	16	0
,, Railage on furniture and books sent from Johannesburg Office	3	0	0
,, Sundry Expenses	0	19	0
,, Bank Charges	2	17	7
Monthly Journal.			
,, Printing, 8 numbers—Nov. '09, June '10 ..	192	16	3
,, ,, Authors' reprints	25	12	5
,, ,, Advertisements	1	15	6
,, Postage and Distribution	33	10	8
,, Stationery, Printing and Typing	10	5	0
,, Balance at Bank on 30.6.1910	501	13	8
	£1,032	15	5

Audited and found correct,

J. M. P. MUIRHEAD,
Honorary Auditor.

E. HOPE JONES,
Assistant General Secretary.

Cape Town, August 5th, 1910.

The South Africa Medal.

SOUTH AFRICA MEDAL AND FUND.

(Raised by Members of the British Association in commemoration of their visit to South Africa in 1905.)

After the conclusion of the Presidential Address in the Lecture Theatre of the South African College Engineering Laboratory, on Monday, October 31, the President (Dr. Thos. Muir) handed the Medal and grant of £50 to Professor J. C. Beattie, D.Sc., F.R.S.E. In doing so, the President said:—

"The third award of the South Africa Medal and Grant has been made to Dr. J. C. Beattie, Professor of Physics at the South African College. Last year's recipient was Dr. H. Bolus, the distinguished Botanist, and on the previous occasion the Medal and Grant were awarded to Dr. Theiler, of the Transvaal Veterinary Service.

"Professor Beattie came to South Africa in 1897 to occupy the Chair of Physics at the South African College, and immediately began the work of the Magnetic Survey of South Africa in conjunction with Professor Morrison, of Victoria College, Stellenbosch. This work has since been carried on by them in various vacations.

"In 1903 Dr. Beattie took a year's leave, which he devoted to continuing the work, and he then visited various parts of South Africa south of the Zambesi. The results of the work up to 1906 have been published by the Royal Society of London. Further work has been carried on since during successive College vacations. The expenses of the work were met by grants from the Royal Society, London (about £1,000), and the various South African Governments (about £2,500), and by smaller sums from the British Association and this Association.

"In 1909 Dr. Beattie again took a year's leave, in conjunction with Prof. Morrison, and the survey was carried out over a large part of Central and Equatorial Africa, Prof. Beattie himself working through to Gondokoro practically by the Cape to Cairo route. This work of 1909 was carried out at the expense of the Carnegie Institution, and the Royal Society (London), with help from Dr. Jameson and Sir Lewis Michell, while the expense was materially reduced by special facilities from the late Government of the Colony of the Cape of Good Hope, the Rhodesian Government, the Government of German South West Africa, and the Sudan and Egyptian Government.

"Since he came to South Africa, Professor Beattie has also carried out other work in Physics, chiefly on the discharge of electricity through gases, the results of which are published in the Philosophical Magazine, and in the reports of this Association."

AWARD FOR 1911.

Notice is hereby given that nominations for the recipient of the award for 1911 will be received by the Assistant General Secretary of the Association, P.O. Box 1497, Cape Town, up to and including 31st January, 1911.

PRESIDENT'S ADDRESS.

ADDRESS

BY

THOMAS MUIR, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.

PRESIDENT.

In days of easily exhausted enthusiasm it is something for a scientific association to have survived seven years, to have made the full circuit of its domain, and now in the city of its birth to be once more seeking to stimulate a zeal for work among individual students, corporate bodies, and the Government itself. With small blame to anyone, the results might have been much less satisfactory—a fact which the pessimists amongst us would do well to remember. In a country at our stage of development, having a small scattered population and few large cities, it was somewhat risky to inaugurate such an association at all, and the risk was not lessened when the resolution was taken to convene it every year. We have only to look at the history of its predecessors in other countries, and especially to the history of the early years of the sister association in Australia, to learn the difficulties that beset the venture, but fortunately also to see that there is good cause to go forward with hope.

The rocks and quicksands in the way are not uncharted, and they are bound to become better known as years go on. There are the difficulties inherent in the nomadic character of the institution, the difficulty of securing the attendance of the same working members from year to year, the consequent difficulty of maintaining continuity of policy, the tendency to encroach on the work of other societies, the tendency of authors to indulge too much in the extremes of technicality, and the still more dangerous tendency to run into excessive popularisation. When we bear all this in mind, we cannot but proffer our sympathy to those who have tried to guide the fortunes of the Association during the past seven years, and express the earnest hope that their coming difficulties will be less and their success still greater.

From more than one point of view it is evident that we start the second seven-year period under propitious auspices. In the first place, it is the year of Union. Such a year ought to prove, as in other instances it has proved, a year of fresh awakening of intellectual effort, a year of increased patriotic desire to study the flora, fauna, and mineral resources of one's country, a year of increased determination to promote the national welfare, and, as one of the greatest ends thereto, the advancement of science. In the next place, we have gained the prestige that attaches to securing for our Honorary Presidentship the name of His Majesty King George the Fifth. Long may he reign, and long may his appreciation of intellectual work stimulate his subjects the world over to promote all literary and scientific interests.

The fact of our Association having His Majesty at its head recalls a great gathering of the parent Association, now about half a century ago, when the actual president of the meeting was our King's grandfather, long affectionately known among the older of us as the Prince Consort, and who even then had by his wisdom of counsel and high personal character endeared himself to the people of the Empire. The address which he delivered on that occasion well merits attention still, and for us to-night has several points of exceptional interest. It sets before us the high ideals which then animated our predecessors; and, when we see what great consequences have resulted from apparently insignificant steps then taken, we ought to go forward with courage and hope.

At the outset he emphasised the objects of the Association, stating that these were "to give a stronger impulse and more systematic direction to scientific inquiry; to promote the intercourse of those who cultivate science in different parts of the Empire with one another and with foreign philosophers; and to obtain a more general attention to the objects of science, and a removal of any disadvantages of a public kind which impede its progress." If we question ourselves as to *our* objects, it is pleasing to find that this sentence is almost verbatim the sentence which stands at the head of the constitution of our own Association. We modestly say "the different

parts of South Africa" instead of "the different parts of the Empire"; we fight shy of "foreign philosophers" and leave them out; and we avow ourselves to be Philistine enough to care for "applied" science as well as "pure" science. But with these trivial differences we seek to follow the old path, believing earnestly that the need is as clamant to-day as it was in 1859.

Again I note that the Royal President took credit for his Association that, in conjunction with the Royal Society, it had suggested an Antarctic Expedition with a view to further the discovery of the laws of terrestrial magnetism, and that the discovery of a continent had been the additional result. It is exceedingly interesting to recall that the expedition referred to was that rendered ever memorable by the discovery of Victoria Land and the Ross Sea, discoveries which led naturally to the recent successes of Scott and Shackleton, to be followed up next year, as we hope, by the crowning triumph of our recent visitor, the *Terra Nova*.*

Still more personally interesting to us was the resolution that the Association should express to Her Majesty's Government, through the proper authorities, its concurrence in the application made by the Royal Geographical Society to the First Lord of the Treasury to further a proposed expedition under Captain Speke "to ascertain if the White Nile has its main source in the Great Nyanza Lake." This was the world-famous expedition which first traversed and made known the kingdom of Uganda, which first saw the Nile issue at the Ripon Falls from the Victoria Nyanza, which led naturally to discovery after discovery in the lake region of Central Africa, and which by coming out at the Nile mouth may well have suggested the Cape-to-Cairo railway.

Lastly, laying aside all consideration of individual schemes, the Aberdeen President of 1859 took a wider outlook and struck a higher note. "We may be justified in hoping," he said, "that by the gradual diffusion of science, and its increasing recognition as a principal part of our national education, the public in general, no less than the Legislature and the

* We also find the President of 51 years ago taking credit for his Association that in conjunction with the Royal Society it had urged "the completion of a classified catalogue of scientific memoirs, which, by combining under one head the titles of all memoirs on a certain subject will when completed enable the student who wishes to gain information on that subject to do so with the greatest ease." Now, out of this effort arose (1) the splendid volumes of the *Royal Society's Catalogue of Scientific Papers*, twelve already published and twelve to come; (2) the long series of *Index Volumes* of the same Catalogue, two of which have been published, and which when completed will be a guide to every scientific memoir of the nineteenth century; and (3) the great scheme for an *International Catalogue of Scientific Literature*, beginning with the twentieth century and extending to seventeen volumes a year. No bibliographical undertaking is ever likely to prove of greater aid to individual workers in all departments of science, and it is a satisfaction to know that from the first the Government of Cape Colony joined the other civilized states of the world in contributing its mite to ensure success. The occasion is not inappropriate to suggest that the other Provinces of the Union should now make an effort to help adequately the same good cause.

State, will more and more recognise the claims of science to their attention; so that it may no longer require the begging-box, but may speak to the State like a favoured child to its parent, sure of parental solicitude for its welfare; that the State will recognise in Science one of its elements of strength and prosperity, to foster which the clearest dictates of self-interest demand." In reading these eloquent words we naturally inquire whether the hope which they express has in fifty years been adequately fulfilled, whether the begging-box has become useless and an occupant of the lumber-room, whether Science has found in the State a beneficeent mother, and has thriven as a well-cared-for child should.

It is questions like these that have led me to select as the main subject of this address "The State's Duty to Science." It was originally suggested that I should use the occasion for the purely historical purpose of sketching the growth of Science in South Africa during the past twenty years. But as almost the only advantage to be got from looking backward is to take lessons from our mistakes, and as in science our mistakes have a knack of being their own remembrancers, I have chosen the more congenial task of indicating what all thoughtful men—men of affairs as well as men of science—consider to be the State's proper attitude towards Scientific Research. Although in so doing it is the future that one must steadily keep in one's eye, there is still no reason why the policy or separate actions of the past should not be incidentally recalled in order to illustrate a dictum or to point a moral. Further, it would seem that no more fitting time could be chosen for speaking generally of the State and its duties than the year in which by the union of four colonies a new State has been set to work out its destiny before an onlooking world.

In all ages the welfare of a State must have been in a greater or less degree dependent on the development of its material resources and on the vigour and intelligence of its people; it is only in comparatively recent years, however, that recognition has been given to the fact that the State must leave nothing of this to chance, but must set itself deliberately, by the use of scientific method, to make the very best of its resources, and to increase the available vigour and intelligence of every one within its borders. Not only so, but it must take suitable precautions that intelligence be universally trained, and be also duly organised so as to give the most effective and productive result. It is no longer enough that the State shall merely welcome and applaud a discoverer when he arises, or merely safeguard a private inventor from being fleeced: on the contrary, it must give of its substance to foster both discovery and invention, and must give legislative help to secure that inventions when made shall not be unfruitful through want of skilled labour or other hampering cause. And if we ask the reason for this change, the answer is that the keenness of international competition has vastly increased, that this has led to serious searching of intellect, that the laws of evolution have in conse-

quence been seen to be applicable to nations as well as to individuals, and that under these inexorable laws the very existence of a State may be imperilled by ignorance or neglect. It is thus more important than ever that statesmen and leaders of the people shall not only be men of probity and high general character, but men of wide knowledge and penetrating forethought. They must have studied and must know all the possibilities of both land and people. On the material side they must have reckoned up the mineral resources, the agricultural resources, the water-power and other forms of potential energy, the harbour accommodation, the waterways, and the advantages of the geographical position for over-sea commerce. On the human side, they must have noted the natural gifts and weaknesses of the people, the best means of developing the former and of correcting the latter; and if it should be that there are varieties of race and colour in the population they must have thought out plans not only for preventing loss of power through internal friction, but for obtaining the close co-operation of all the races in the general national interest. In the future, it is only in a relative sense that there will continue to be "hewers of wood and drawers of water": the State that aims at being in the forefront will have to see that even its wood-hewing and its water-drawing are done intelligently and to the best advantage. Further, the exploitation of any race in the interest of a higher race will be fatal folly when the need exists for exploiting all races in the interests of the State.

These considerations make it readily appear that the first great duty of the State towards science is to provide an effective and comprehensive system of National Education. In the lower stages of the system direct and formal instruction in science need not bulk very largely: what is essential is that the pupil shall throughout his course be trained to observe, to think, and to reason. In the middle stages—the stages covered by Secondary Schools of all classes—the actual study of science, and especially of scientific method, must form a larger and ever-increasing part of the curriculum. Under neither of these heads, however, need we enter into detail to-night: it is sufficient for our present purpose to insist in connection with both on the desirability (1) of fostering rather than repressing the natural curiosity of the young, (2) of constantly recurring to the study of things in supplement to that of words, (3) of training the hands in the use of appropriate tools other than the pen, (4) of gradually introducing research methods into class-room work. It is the neglect of this advice that has been a main cause in the retardation of science: it has also helped to make school-life a byword for dulness, and in many cases made the after-life unintellectual and even trivial.

When we come to the higher stages—the stage of the University, and more practical institutions co-ordinate therewith—the interest in our subject naturally increases, for there we look not only for instruction in science and training in scientific

method, but for a steady flow of fresh contributions to the stock of human knowledge. That this last is a legitimate expectation is now the received opinion throughout the whole civilized world. In accepting it, too, we have but returned to the original conception of a University—a conception that, in the course of a long period of years, had gradually come to be forgotten in English-speaking countries. The evil results of this period of somnolence at length became so striking, not to say alarming, that in May of 1870 a Royal Commission was appointed in England to make inquiry into the whole matter. It may safely be said that no stronger Commission ever sat on a cognate subject, and that its long series of reports are models of clear statement and wise counsel, which even to-day it would be difficult to improve upon. "We have no doubt," one weighty report says, "that for a professor the duty of teaching is indispensable, but we agree that original research is a no less important part of his functions. The object of a University is to promote and to maintain learning and science, and scientific teaching of the highest kind can only be successfully carried on by persons who are themselves engaged in original research. If once a teacher ceases to be a learner it is difficult for him to maintain any freshness in the subject which he has to teach; and nothing is so likely to awaken the love of scientific enquiry in the mind of the student as the example of a teacher who shows his value for knowledge by making the advancement of it the principal business of his life." How far the great English Universities then fell short of the ideal here indicated may be gathered from the writings of the time. On the monstrously-developed examination-system much of the blame had of course to be thrown. When it was asked what the Universities did with their endowments and equipment, a voice from Cambridge said "they perform the functions for too many of their students, of first-grade schools merely, and that in a manner about which opinions are divided; and superadded to these is an enormous examining engine, on the most approved Chinese model, always at work." Another writer advised that in order to be honest the University ought to put up a large brass plate with the inscription "Examinations held here." And there were endless other well-deserved sarcasms from those who knew the facts best. Of the agitation, the inquiry, and the plain speaking much good came, and the English Universities of to-day show in consequence a very different character and spirit. The difference may not be all that earnest reformers still desire, but who in South Africa can with any conscience throw a stone at the offenders? Even so late as 1901, when numerous reforms had been effected in England, a great educationist and chemist, in drawing attention to the function performed by Universities on the continent of Europe, wound up with the passionate cry "*Their* universities have always been schools of research, of inquiry; unless and until ours become such, and our youth are trained to advance, there can be no hope for us. God help us to make the change before it is too late!" If this be the prayer con-

sidered suitable for England when the present century began, what petition will suffice to-day for South Africa, which, as regards University research, stands well in the rear of the England of forty years ago? Are we to be encouraged to hope that one result of this year of Union will be a serious effort to uproot our low ideals of University work, and to sow in their place the seeds of true learning and research? Fortunately, in one or two of the *Colleges* a few individual teachers have set an excellent example, striving as far as their scant leisure permitted to advance the boundaries of their subject. All honour to them, and may more and more of their students imbibe their spirit, and unite to press on the question of University Reform and the removal of a deeply engrained stigma.

Co-ordinate in a sense with Universities are public Museums and Libraries, the link of connection being that besides being intended for the promotion of research they have other purposes to serve. All of them profess to aim at the instruction of the people; but in the case of museums and libraries this instruction is avowed to be mainly of a popular character, and in the case of museums it often differs very little from that more or less elevated amusement called sight-seeing.

As regards *Museums*, especially local museums, we have to note that in the first place very seldom have their founders had the purposes of real research in their minds. Usually, indeed, the original object has been the formation of a collection of animals, plants, and mere curiosities, with the result that if anything profited thereby it was Natural History and Archæology alone. Further, a fresh museum has almost uniformly been started without any intention of supplementing or co-operating with those already in existence: much loss in effectiveness has thus been sustained. How best to remedy these initial defects has been a long-standing problem with scientific men, and it is now fairly well agreed (1) that the museums of a country should, for purposes of co-ordination and co-operation, be under some common control, (2) that while in local museums appropriate specialization should be encouraged no science should be wholly neglected, (3) that both of the main purposes, instruction and research, should receive adequate attention in all museums, (4) that in the case of the Central Museum the purpose of research should be paramount, all the chief officers being chosen because of their ability to advance the knowledge of their own subjects. Though much is lacking under all of these heads in South Africa, it is also unquestionable that under all of them for a considerable number of years much has been accomplished, and that at any rate the tendency of administration has been along lines almost uniformly good. In particular, we in Capetown have in the South African Museum, with its *Annals*, a scientific agency of great national value and of immense promise for the future. Sad it is to think that, while its collections have been rapidly growing in magnitude and importance, the accommodation for exhibiting them remains as it was fifteen years ago.

As regards *Libraries*, the state of matters is not greatly dissimilar. There are more of them, it is true: but if the list be

arranged in order of merit we have not got far down it when we find that we have parted company with scientific research. Indeed, the libraries that cater for anyone else than the so-called "general reader" are exceedingly few in number: co-operation is thus at least as necessary as in the case of museums. This is especially true in regard to scientific journals and the publications of scientific societies. The number of these is nowadays so great that a long purse is necessary for the maintenance of a complete collection: but by neglecting co-operation we make matters worse than they need be. Here in Capetown, for example, we have four or five libraries that purchase scientific serials, and, though the libraries are within short distances of one another, duplicate and triplicate copies of some journals are to be found on their tables, while other journals equally important are neglected by them all. The time surely cannot be far distant when this will be rectified, when too the importance of such reference-libraries will be better appreciated by the State, and when the South African Public Library, having its special annual grant for reference-books restored to it, will take the lead in a scheme of co-operation calculated to meet the wants of all engaged in scientific or literary research.

When thus dealing with the functions of Universities, Museums, and Libraries, I have been in a manner viewing the State as an *educationist*. I now wish in the same way to invite your attention to the State as a *landlord*. With an extensive and varied property calling for development, one of the first and most urgent duties is to have it surveyed and inventoried under every needful heading. In the first place, it must be accurately mapped; in the second place, its surface constituents and rock-formations must be ascertained and registered; in the third place, the animal life of every district must be put on record; in the fourth place, the same must be done with its plant life; and, lastly, its water supply, rainfall, and other climatic factors must be observed and tabulated. There thus arise as necessary scientific departments of the State's work—the Topographical, Geological, Zoological, Botanical, and Meteorological. The fact that some of these subjects are incidentally dealt with by college lecturers and private students is no satisfactory reason for negligence on the part of the State. All such outside aid, it must be remembered, is subject to the uncertainties of personal liking, fashion, and caprice; and consequently is in its nature fitful and unreliable in an emergency. Besides, much of the work wanted to be done requires continuous attention over long periods, so that efficiency can only be secured by the existence of a permanent staff. It would be unwise, of course, in organizing such Government Departments to neglect consideration of the amount of outside work that might be reckoned on: what is urged is simply that such Departments ought to exist, be they great or be they small. When, with this in mind, we turn the searchlight on ourselves it might at first sight appear that though separate Government Departments do not exist in Cape Colony for Topography, Geology, Zoology, Botany, and Meteor-

ology, all these subjects have had a fair share of Government attention and Government funds. When we look closer, however, we see things that cannot fail to awaken regret. A Government Department for Topography has long been in operation, but money for the higher classes of work has been scanty, and consequently a detailed and thoroughly accurate map of the Colony is still a long way off. Geology, after years of extravagant expenditure on temporary experts, was entrusted in 1895 to a Government Commission, and since then has been an illustrative model of the good to be derived from pursuing the policy just indicated. Zoology has been left to the Museums and private workers, and, all circumstances considered, has not suffered as an outcast might. Botany has had the same fate, although the votes of the Agricultural Department would seem to indicate that it is more of a favourite. There we find a small sum set down for the upkeep of a herbarium, another small sum for the furtherance of the *Flora Capensis*, and, by comparison, a surprisingly large sum for the maintenance of Botanic Gardens. The latter purpose is altogether praiseworthy from our Association's point of view, but one fears to learn how small a contribution to science the said gardens make. If the total sum voted, which is a thousand pounds more than is spent by the Government on Geology, had been set apart for the advancement of Botany on the same conditions, the progress of the subject would have been very different to-day. As regards Meteorology, the last of the five, one finds it hard to speak with patience, so persistently has it been starved. Possibly this is in part explained by its dis-association from the Department—the Agricultural Department—which might naturally have taken an interest in it: but whatever the reason, there is no doubt that nothing more urgently calls for serious attention on the part of the Government.

I am reminded here that the owner of an estate does not restrict himself wholly to his dry-land resources, and that therefore a sixth survey should have been included in the foregoing list. This I do not deny, but by separating it from the others I secure the desired advantage of additional emphasis. The science with which the suggested survey is concerned—namely, Marine Zoology—is not less important than any of the five others, and at one time it was so viewed by the Cape Government. A serious change of attitude supervened, influenced no doubt by economical considerations, and the extreme step was taken of practically blotting out the whole subject from the Government books. I am one of those who, without knowing any of the facts of the case, feel that this was nothing less than a misfortune. It is not for an instant pleaded that there was no need for economy, or that an alternative course had been suggested as possible: it is merely deplored that for any just cause whatever it should have been found necessary to cut off from all support—even the smallest—an agency capable under due supervision of doing real good to the State. The backwardness of the step lies in ignoring the fact that an inexpensive continuous work is better in such cases than a liberally-

aided discontinuous one. It would be a matter for deep regret if the historian of our country should ever find it necessary to record an incident even distantly resembling that connected with the name of the great French chemist Lavoisier. In the Reign of Terror Lavoisier was one of those marked down for death, and his enemies at length laid hands on him. In vain some of those who knew the value of his life to science pleaded for his release. They next entreated that his execution might be stayed until he had completed a piece of research on which he was then engaged. But his captors were relentless. "Away with him!" they cried, "the Republic has no need of savants!"

Attention has next to be called to the State's duty in a third capacity, namely, as general *Health-Guardian*. Fortunately this, though involving consideration of a number of sciences (Entomology, Bacteriology, Mycology, etc.), need not be enlarged upon, it being self-evident that the bodily and mental fitness of the people is all-important in the life-struggle of nations, and that it is almost equally momentous that animals and plants useful to man should be protected from the ravages of disease. Further, there is the satisfactory reason that in dealing with such matters South African Governments have been on the whole sympathetic and in some directions markedly liberal. Here again, however, and perhaps in a special degree, it is necessary to give warning that the State should not burden itself with work proper to individuals and private corporations, but should confine itself to needful scientific work which other agencies cannot accomplish. It should never be forgotten that the State which discourages self-help is undermining its own strength.

Thus far we have been considering sciences with direct practical applications; indeed, the reason for considering them at all has been in the main because of the existence of these applications,—because the sciences bear more or less immediately on the welfare and prosperity of the State. What then are we to say of the so-called *Pure Sciences*—sciences from which the State or its people cannot hope to obtain any immediate benefit? Our answer is—and it ought to be given with entire frankness—such sciences must be content to take a second place. The State, we feel, has a perfect right to expect something tangible in return for its outlay: and, its supply of funds being limited, it is bound to pass in review before it any proposed series of scientific schemes, separating them out into practical and unpractical, and thereafter sifting the practical into those that are urgent and those that are not. No one, for example, can reasonably complain because the Government of Cape Colony has for years preferred to subsidize the study of Geology rather than the study of Bushman paintings, the study of Bacteriology rather than the study of Pure Mathematics: or because the Union Government was not so liberal to the *Terra Nova* Expedition as geographical enthusiasts would have wished it to be. What could

only have justified complaint in the latter case would have been conclusive proof that public money was being put to a worse purpose otherwise. A manifest danger, however, besets the discriminators between rival schemes, it being far from easy to foresee what particular research will prove fruitful of practical applications and what will not. How often has one seen the pure mathematics of to-day change into the applied mathematics of to-morrow, and the previously despised insect-collector be hailed shortly afterwards as a benefactor of mankind! All that one can hope for is that those with whom such decisions rest will always take the best advice available. Of recent years European Governments have tended more and more in such cases to consult their great leading scientific corporations: the Government of the Union may in like manner find our own Royal Society a willing and useful guide. I would merely add as a fact worth ruminating on that the States which have differentiated least between pure and applied science are the States which lead the world to-day.

While thus whole-heartedly urging the great importance of science on those who may be called to administer the affairs of state, it would be unfair to ignore the difficulties and troubles which well-disposed administrators have experienced in their dealings with scientific men, or "experts," as they prefer to call them. The complaint of the most moderate of these critics is that the man of science is normally unpractical, and that his value to the State is marred by eccentricities due to over-study or excessive specialization; and those critics who are not moderate and who love a biting phrase better than strict accuracy, say that when he is not an astute self-seeker he is either a mooning pedant or a pernicious crank. Now, in regard to this I should first wish to ask whether it be not the case that the failure of the scientific expert is often due to causes wholly outside himself. Time and again one has seen a man chosen for his high qualifications in a special branch of knowledge, and then set, not to the work of extending this knowledge by investigation, but to the absolutely diverse work of "running" a Government office or carrying on a purely business undertaking. Failure, nine times out of ten, is thus inevitable: so rare is it to find the successful student and the capable administrator combined in one. Surely it is the merest commonsense to urge that if both sets of qualifications be wanted reasonable care should be taken either that they are possessed by the same individual, or that a practicable arrangement involving their separation has been previously devised. In the next place, one naturally asks whethe it be not the case that the scientist's faults are no more conspicuous than those discernible in men of other walks of life; whether the eccentricities of his critics are one whit more innocent than his own; and whether, generally, there be not at least as much truth in the companion picture of that most unfortunate product of modern public life, the pushful, noisome sciolist, who has to acquire merit with his party by fair means or foul, and who in pursuit of this will get up the technical glossary of a science in a night, and

having suitably freed the glossary from its alphabetical order, will reproduce it as a serious disquisition, to be delivered in the morning with unctuous complacency and an air of supreme conviction. One thing certain is that in particular the appellation "self-seeking," as applied to men of science, is singularly unfortunate, for, though the scientist with such a bent is not unknown, one's whole experience is that he is a comparative rarity, and that the more zeal a man has for science the less regardful he is of self. Indeed, it has been maintained that in the virtues of unselfishness and truthfulness the man who has chosen the pursuit of science for his life-work noteworthily excels. No less an authority than Helmholtz, himself a man of the world as well as a great investigator, has spontaneously testified to this, speaking with enthusiasm of the scientific man's "Sittenstrenge," and his "uneigennutzige Begeisterung." Unfortunately, it is possible that this "Sittenstrenge" is exactly what our public men would consider an eccentricity, their shortsightedness leading them to mistake a surface freckle for a deep-seated defect. Be all this as it may, however, it is important to urge on both sides the fact that the man of science and the man of affairs, whatever their respective frailties may be, have need of each other, and must therefore in the future strive to know each other better, and learn to co-operate more effectively in the interest of the State. To this end he who aims at state-administration must seek to possess other qualities and other aptitudes than those of the mere party-politician, so that, besides doing his own proper work well, he may be better able to gauge the value of pure scientific work and be the better fitted to sympathize with the ideals and aspirations of even the extremest of specialists. On the other hand, the specialist must aim a little more at width of outlook and knowledge of men and affairs, must seek to moderate his exaggerated estimate of the importance of his own little domain, and must try to see good in the labours of other specialists in fields far distant from his own, never forgetting that *all* fields are but perfectly-fitted portions of a kosmic whole, and that, as the botanist and the astronomer in particular must come to know—

> Thou canst not stir a flower
> Without troubling a star.

It would be a neglected opportunity if we did not note in passing that the need for a good understanding between the devotee of statecraft and the student of science is only part of a much wider need. Men who aspire to be leaders in municipal affairs, in commerce, in trade, in the manufacturing industries, in agriculture, must all come to know how substantially dependent they are upon science, and how indeed in a very real way they must become more and more scientific themselves in the conduct of their affairs. With them also the day is gone when rule-of-thumb is a sufficient guide. Even sound common-sense, so great a stand-by in the past, is no longer enough: what is wanted is that glorified form of common-sense known as scientific method. Practical men in every line of life are beginning to see this, though they may not use the term. In

plain language, what it means is the employment, at every stage of a process or undertaking of the means best suited to attain the desired end. And as a method it is always essentially the same, no matter how the desired end may vary,—whether the latter be, as we in Cape Colony have seen it to be, the sanitation of a town, the tracking of a crime, the repression of a native rebellion, the fighting of an invading disease, or the capturing of a market for fruit or wool. In all of these there was the same need for collecting accurate data, using all previously acquired relevant knowledge, planning skilfully a course of procedure, selecting wisely the human agents necessary, and then prosecuting with steady persistency the plan resolved on.

I need hardly say, in conclusion, that all that the most enlightened State can do will never be fully effective without a continuance of that zeal and devotion on the part of the *private worker* which has been so conspicuous in the past history of science. And, fortunately, in the course of evolution man has become so constituted that a stoppage of the supply need not be feared. Many will still be found willing and eager to work for the work's sake, whether the State does its duty or the reverse, merely resting on the assurance that "Nature never did betray the heart that truly loved her." The grand example to all of us is that of Faraday. To read of his devotion and disinterestedness is at all times an unfailing delight. Although the sciences which he cultivated were full of practical applications he never once sought to make them profitable. Though others took them up and grew rich on them he looked on in calm contentment without a trace of envy or regret. Even when the mere use of his name would have brought him wealth no temptation could overcome him. For about half a century he lived in comparative retirement beside his work in the Royal Institution, endowing the world with the revelations of his genius and seeking nought in return, even refusing posts of the greatest honour and declining titles eagerly sought for by men in a higher position than himself. And after all, a life like his, spent in research, does not go unrewarded. It may be oftenest its own reward, but that this is ample all real workers will bear witness. That I may the more deeply impress this conviction on the minds of the younger members of the Association, I refrain from using my own words, quoting instead those of a great living biologist:—"To aid in the production of new knowledge," he says, "is the keenest and purest pleasure of which man is capable, greater than that derived from the exercise of his animal faculties in proportion as man's mind is something greater and further developed than the mind of brutes. It is in itself an unmixed good, the one thing which commends itself as still 'worth while' when all other employments and delights prove themselves stale and unprofitable." To this I merely add, as a consolatory echo, the old English couplet:—

When land is gone and money spent
Then learning is most excellent.

Section A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE, AND GEOGRAPHY.

President of the Section:—Professor J. C. Beattie, D.Sc., F.R.S.E.

WEDNESDAY, NOVEMBER 2.

The President delivered the following address:—

EARTH MAGNETISM, WITH SPECIAL REFERENCE TO SOUTH AFRICA.

It is always a matter of difficulty for a president of a section of our Association to decide on the subject of his address. In the first place, each section embraces several sciences, and no one man can deal with the whole of them; secondly, if one science be chosen the speaker runs the risk of losing touch with his audience by taking up in detail some particular division of it, or of wasting time by trying to recapitulate the advance of the whole. For my own part I feel that I cannot do better than choose one part of physics and limit myself to a portion of that; the part is magnetism, the portion is earth magnetism in South Africa.

I shall begin by giving a short summary of what we know to-day about magnets, and then give you an account of the order in which the facts have come to light in history. The two most striking properties of a magnet are first, its attractive power, and, secondly, its directive property; the latter is usually specified, for that great magnet, the earth, by giving the magnetic declination and the inclination. We further know that these two quantities have different values at different parts of the earth, and that these values change from year to year, that they vary slightly with the time of day at which they are observed; that they may be very seriously changed in value for hours together by what we, for want of a better name, call magnetic storms. I propose to shortly state when these various facts were discovered, and then to tell you what we know about them in this country.

The derivation of the word magnet is of interest. Benjamin* gives a full account of the various explanations which have from time to time been put forward. Pliny, for example, copying Nicander, states that a certain stone was called the Magnes Stone, because a shepherd Magnes "while guarding his flock on the slopes of Mount Ida, suddenly found the ferule of his staff and the nails of his shoes adhering" to it. The derivation of the word usually accepted is from Magnesia, in Lydia, a town near which was a deposit of the natural magnetic stone familiar to the ancients. The attractive power was the first property observed; it is the foundation of many stories. I

*Park Benjamin: "The Intellectual Rise in Electricity." Longmans & Co., London. 1895.

need only quote one—from "The Arabian Nights." There we read:—

"To-morrow we shall arrive at a mountain of black stone called lodestone; the current is now bearing us violently towards it, and the ships will fall in pieces and every nail in them will fly to the mountain and adhere to it."*

The references to the magnet in the writings of the ancients further show that the writers were aware that the attraction was confined to iron; or, at any rate, it was not indiscriminate. They knew also that the magnet had the power of communicating this power to other bodies. Of course, there were many properties attributed to the magnet which have since been found to rest on great imaginative power, rather than on fact. We find it stated, for example, that the magnet attracts flesh, that it is effective in the cure of disease, that it cures baldness, that it affects the brain, that it acts as a love philtre, that it loses its power when rubbed with garlic, and many other equally imaginative statements.

At what date the directive property of a magnet was first discovered is not recorded. It is almost certain that it was known to the Chinese before the beginning of the Christian Era. In various writings there are descriptions of the so-called south-pointing carts, of which the distinctive feature was a doll with outstretched arm,attached to a pivoted magnet, which always caused the arm to point to the south. In Europe the knowledge of the directive power was acquired much later; from a careful examination of more than seventy Greek and Latin authors, covering the period from the sixth century B.C. to the tenth century A.D., no mention of the directive powers of the lodestone has been discovered;† the first European writer who refers to it and to the use of a compass is Neckam, who wrote about the end of the twelfth century. By the middle of the thirteenth century a more exact knowledge prevailed, and the following summary of the magnetic phenomena, described by Peter Peregrinus, shows how much was known at that date. Peter wrote, on the 12th of August, 1269, from the trenches at the Siege of Lucera. He explains how a magnet, when divided into two parts, results in two halves, each of which has two poles; how the one pole of a magnet always points to the south, and the other to the north; he gives a description of the mariner's compass, which in its essentials is the same as the one in use to-day; he points out also that the directive power of the magnet entails the existence of something outside the magnet; he himself maintained that the directive power of the magnet was due to a certain region of the heavens; there were other explanations advanced, however, in those times, one attributing the directive power to the attraction of magnetic mountains near the earth's pole, and another which gave the Pole star as the cause.

The next discovery was that of the magnetic declination. In recent years Hellmann and Wolkenhauer have shown that this

*Benjamin: *op. cit.*, p. 96.
† Terrestrial Magnetism, Vol. VIII., p. 177

was known in Europe before Columbus's first voyage; his observations in 1492 were, however, the first to bring out beyond dispute the fact that the compass did not point in the same direction at all places on the earth's surface. For long after Columbus's time this knowledge was confined to seamen only; these took it up very seriously, and it was the custom for the early navigators on long voyages to determine the magnetic declination at different places *en route*. One of the first to make such determinations was de Castro.* While on a voyage from Lisbon to Goa, 1538-1541, he gave the first information of the declination values in the South African Seas. Near St. Francis Bay he found the value 1° 30′ E., in June, 1538; off what is now East London, the value is given as zero for the same year, while at the Mozambique anchorage which was reached on August 10th, 1538, the value was 6° 45′ W. I may also mention Corn. Houtmann, another of the early seamen who made observations in South African waters. He determined the declination in or near Mossel Bay on August 4th, 1595, and found it to be zero.

Not only has the magnet a declination; it has also an inclination. The discovery of this is first mentioned in 1544 by Georg Hartmann in a letter to Prince Albrecht of Prussia. The contents of this letter were not published, and the inclination was again discovered by Robert Norman, who made his knowledge known in a little work called "The Newe Attractive," published in 1581, the first work on terrestrial magnetism. He determined the dip in London, in the year 1576, to be 71° 50′ N. The next determination of the dip was also made in London in 1600, and by Gilbert, a man whose name must always receive honourable mention in any account of the development of magnetical discoveries and theories.† His book, "De Magnete," was published in 1600, and contains a most complete summary of the properties of magnetic bodies, as they were known at that date. Gilbert's own contribution is the suggestion that the earth is itself a great magnet. The heading of chapter 17 of Book I. is

> "That the globe of the earth is magnetick and a magnet; and how in our hands the magnet stone has all the primary forces of the earth, while the earth by the same powers remains constant in a fixed direction in the universe."

He illustrated his argument by reference to a spherical steel magnet called a terrella, with this and a small magnet he shows how the direction of the earth's field must vary from place to place. His views on declination and inclination he illustrated by the same means. He believed—what we now know not to be the case—that the earth's magnetic poles coincided with the geographical ones; he was not aware, however, that the vari-

* Van Bemmelen: "Die Abweichung der Magnetnadel": Observation. of the Royal Magnetical and Meteorological Observatory at Batavia. Vosl XXI. Supplement.

† William Gilbert of Colchester, physician of London. On the magnet, magnetick bodies also, and on the great magnet the earth; a new physiology, demonstrated by many arguments and experiments. Chiswick Press, London. 1900.

ous magnetic elements suffer change from day to day and from year to year.

The first of these changes discovered was the secular change in declination. Gellibrand, a professor of mathematics at Gresham College, pointed out that the declination at London did not always have the same value; to uphold his view he published the results of observations in 1580, when Borough and Norman had found the value 11° 15′ E.; in 1622, when Gunter determined it as 5° 56½′ E., and his own determination in 1634, when the value was 4° 6′ E. The secular change in the dip was well known to Wilke, who published, in 1768, the first dip chart. Wilke pointed out that within 150 years the dip in London had changed by more than 3°.

A periodic, as distinguished from a secular change, was discovered in 1722, when Graham, a London clockmaker, after making a great many observations at different times of the day, announced that the declination had a daily change. His result was confirmed by Celsius, in Upsala, in 1740. Since then exacter observations have shown that the dip and the field strength have also a daily variation.

In addition to the various changes mentioned above, the magnetism of the earth undergoes changes, sometimes local, sometimes extending over the whole earth. These magnetic storms, as they are called, were first brought into notice by Baron Humboldt, who attempted, in 1806, to make continuous observations of the declination in Berlin. It was not, however, till 1828 that he was in a position to carry on this work to his satisfaction; in that year he had three observatories established, in Paris, Berlin, and Freyburg respectively. He was able to show by comparing the records of these three stations that a magnetic storm would sometimes be felt simultaneously at all the three stations; at other times, however, one station might indicate a storm, while the two others were undisturbed.

This general description of the evolution of magnetism in connection with the earth may be fittingly brought to a close with a reference to the German mathematician and natural philosopher, Gauss, who may be looked on as the father of modern earth magnetic studies. Gauss put forward in his "Allgemeine Theorie des Erdmagnetismus" (1839) what is to-day known as the Gaussian theory of earth magnetism. Previous to this date he had laid down a method of determining the intensity of the earth's field in absolute measure, and had, along with Weber, devoted much time and labour to improve the methods of observation, and to collect the results which were buried in different libraries and archives throughout Europe.*

I shall now proceed to give a summary of the work that has been done in South Africa—meaning by that, roughly, Africa south of the equator. Evidently, for such a great area, observations must be taken at many places, and as they cannot be taken simultaneously the first essential is to have some accurate

* Gauss: "Gesammelte Werke." Band V.

method of reducing all observations to a common epoch; that is to say, we must have the necessary knowledge of the secular and the periodic variations. I shall begin, then, by stating what means we in South Africa have for that. These periodic variations can only be studied properly at a permanent station, where continuous records of the various elements can be made. The only permanent station at the present day in our part of the world is the Royal Albert Observatory at Mauritius (1895). There were permanent stations at St. Helena (1840-1845) and at the Royal Observatory of the Cape of Good Hope (1841-53). Neumayer also speaks, in the introduction to Berghaus's "Atlas des Erdmagnetismus," of such a station in Portuguese West Africa at St. Paul de Loanda; it also has disappeared. Continuous records were also taken for a few years at Dar-es-Salaam. At the present day the most crying want for the study of the magnetic state of this part of the world is the establishment of such a station. A history of the Cape station and the attempts to revive it will be found in the report of the Kimberley meeting.* For the study of the secular changes a permanent station is also necessary; it is now becoming more and more evident, with the accumulation of fresh data, that the secular changes are much more complicated than was previously supposed. If, for example, we are told that the declination at Cape Town was 30° 2′ W. in 1866, and 29° 2′ W. in 1897, it would not be correct to say that the secular change in that period was a decrease in declination of 1′.93 (approximately) per year; still less it is possible to state what the change was before 1866 or after 1897. At the present day all we can do is to observe as carefully as we can the mean values for two successive years, and obtain from them the change in that period. The following table gives the values of the changes per year at the Royal Observatory, Cape Town:—

TABLE No. I.

Year.	Declination.	Yearly Change.	Dip.	Yearly Charge.	In terms ot γ Hori zontal Intems.	Yearly Charge.
1841 ..	29° 6·2′ W.	..	53° 9′ S.	..	..	..
1842 ..	29° 6·0′ ,,	— 0·2′	53° 12′ ,,	+ 3·0′	20960	..
1843 ..	29° 5·0′ ,,	— 1·0′	53° 19′ ,,	+ 7·0′	20890	— 70
1844 ..	29° 6·2′ ,,	+ 1·2′	53° 36′ ,,	+ 17·0′	20690	—200
1845 ..	29° 7·4′ ,,	+ 1·2′	53° 31′ ,,	— 5·0′	20820	+ 130
1846 ..	29° 9·2′ ,,	+ 1·8′	53° 33′ ,,	+ 2·0′?	20800	— 20
1847 ..	29° 12·4′ ,,	+ 3·2′	53° 41′ ,,	+ 8·0′	20770	— 30
1848 ..	29° 14·0′ ,,	+ 1·6′	53° 47′ ,,	+ 6·0′	20720	— 50
1849 ..	29° 16·4′ ,,	+ 2·4′	53° 52′ ,,	+ 5′	..	..
1850 ..	29° 18·8′ ,,	+ 2·4′	53° 58′ ,,	+ 6′	20660	..
1851 ..	29° 20·9′ ,,	+ 2·1′	54° 2′ ,,	+ 4′	..	..
1852 ..	29° 22·9′ ,,	+ 2·0′	54° 4′ ,,	+ 2′	..	.

* J. C. Beattie: "Magnetic Observations in South Africa." Report S.A. Ass. for Adv. of Sc., Johannesburg (1905) and Kimberley (1906), p. 170.

A glance at the above shows how the changes in the different elements vary from year to year, and how necessary it is to proceed with caution when using even an interpolation formula.

A further complication becomes evident when, instead of confining ourselves to one place, we examine the secular and the periodic variations at different places during a common period. I cannot, unfortunately, give you the results for two separate stations in recent years, but must confine myself to the secular changes observed at Cape Town and in St. Helena about the middle of last century. The following table, in conjunction with Table No. 1, illustrates the point to which your attention is called.

TABLE NO. 2.

St. Helena.

Year.	Declination.	Change.	Date.	Dip.	Change.
1841–2 ..	23° 11·3′ W.	..	1840	21° 15·1′ S.	..
1842–3 ..	23° 17·4′ ,,	6·1′	1841	21° 26·4′ ,,	11·3′
			1842	21° 25·0′ ,,	—1·4′
1843–4 ..	23° 24·0′ ,,	6·6′	1843	21° 45·4′ ,,	20·4′
1844–5 ..	23° 32·3′ ,,	8·3′	1844	21° 55·9′ ,,	10·5′
1845–6 ..	23° 40·6′ ,,	8·3′	1845	21° 55·5′ ,,	9·6′

We thus see that the secular variation must be the subject of special study before the observations necessary for a satisfactory knowledge of the magnetic state of a country can be reduced to the epoch.

A considerable amount of information bearing on the secular changes since 1600 in and around Africa has been derived from observations made by travellers, from ships' logs, and from the results of "The Gazelle," "The Challenger," "The Discovery," the work done under Ross, and the determinations made by officers of our own and other navies. Most of these results deal with the declination, and I should like to bring to your notice in particular the work of Van Bemmelen* He has, with great pains, gathered together over 5,000 observations from different voyages, and has shown the results of a series of isogonic charts of the world, for the epochs 1500, 1550, 1600, 1650, 1700. Some of these charts you see before you, in so far as they refer to Africa. In addition, the isogonic charts for 1800 and 1885 are shown. A glance enables us to see many interesting changes which have taken place during these periods.

In Africa, south of the Zambesi, an attempt has been made by Beattie and Morrison to obtain the approximate values of the secular changes. Certain stations in different parts of the Union and Southern Rhodesia have been re-occupied during the last ten years, and it is proposed to continue similar observations in the near future.† The results obtained up to the

* Van Bemmelen: *Loc. cit.*

† The money necessary for this part of magnetic work in South Africa has been contributed by the London Royal Society, the Government of Cape Colony, and the Carnegie Institution of Washington.

present time for the dip and the horizontal intensity are shown on Charts I. and II. respectively, and that for the declination up to 1906 on Chart III. In connection with Charts I. and II. it is to be noted that they really contain the secular changes for two distinct periods, one from about 1900 to 1904, the other from 1903 to 1908. The stations common to the two periods have in each case two numbers attached to them; the upper number in each case refers to the later period. The results at Pretoria, Potgietersrust, Newcastle, Illovo River, and Ginginhlovu refer to the later period. The other stations with a single number refer to the earlier period. The most striking result in the case of the secular changes of dip is the decrease in value as one goes north and east; the yearly change in the Cape Peninsula and along the south coast of Cape Colony is an increase of southerly dip amounting to between 8′ and 9′ per year. In the Transvaal the value is about 6′, and in Natal between 3′ and 4′. Another point to be noticed is the fact that the rate of change at the present time is decreasing. In connection with Chart II., in which the secular change of the horizontal intensity is given for the same periods, we see that the rate of decrease is less in Bechuanaland and Rhodesia than it is in Natal, and the latter change again less than over the Cape Colony. In the case of this element the change shows signs of increasing at the present time. In Chart III. the most striking fact is the extremely high values of the declination secular change along the eastern side of the continent; the figures in this chart all refer to the earlier period when in Cape Town the yearly decrease of declination was about 4′, while the change along the east coast from Port Elizabeth up to Beira was about 10′. It will be noticed that the secular change of declination shown in the earlier charts in their main outlines can only be a rough approximation to the truth; the isogonics do not keep the same relative positions throughout the centuries.

The charts giving the isomagnetics for the earlier epochs, prepared by Van Bemmelen and others, have been published comparatively recently. The first to make use of this method of showing magnetic results by means of isomagnetics was Halley. His "Tabula Nautica," published probably in 1701, gives the isogonics for the Atlantic and the Indian Oceans; he does not attempt to draw the lines over the continents. Halley himself says:—

"What is here properly New, is the Curve Lines drawn over the several Seas, to show the degrees of the variation of the Magnetical Needle, or Sea Compass: Which are designed according to what I myself found, in the Western and Southern Oceans, in a Voyage I purposely made at the Publick Charge, in the year of our Lord 1700, or have Collected from the Comparison of several Journals of Voyages lately made in the Indian Seas, adapted to the same year."

He goes on further to say that the line of no declination—he uses the sailor's term, variation—passes near "the Bermudas, the Cape de Verde Isles, and St. Helena," and that

"This Chart, as is said, was made by observations of the year 1700, but it must be Noted, that there is a perpetual, tho' slow Change in the Variation,

almost everywhere, which will make it necessary in time to alter the whole System: At present it may suffice to Advertise, that about C. Bonne Esperance, the West Variation increases at the rate of about a Degree in Nine Years."

As you see, the lines in this first magnetic map are very regular and show no disturbances. They are derived from observations at a comparatively small number of places, and to-day we should classify them as terrestrial rather than true isogonics.

It is not necessary to give a complete list of the various magnetic charts of the world published since Halley's time, in which the isomagnetics in the African seas are given. Such a list can be consulted in Hellmann's latest work.* The first magnetic map dealing solely with Africa dates from 1798. It gives the isogonics, for the epoch 1793, in the seas round Africa; South Africa comes in with the rest of the continent. It is entitled, "Chart of the Lines of Magnetic Variation in the Seas Round Africa. James Rennell, May 18th, 1798," and is published in an account of Mungo Park's Travels, in an appendix by Major Rennell.†

In the explanatory note accompanying the map, Rennell says: "It appears on inquiry that the quantity of variation is no more known within the continent of Africa than within that of New Holland. And it happens, moreover, that the lines of equal quantities of variation do not run across Africa with that degree of regularity and parallelism which takes place over a great part of the Atlantic and Indian Oceans (at least this is what appears clearly to my judgment); so that it becomes necessary to enquire what quantity prevails in the surrounding seas, and what the general direction, as well as the particular nature and tendency of the curves of the lines of equal quantities. . . . . The theoretical part belonging to the interior of Africa is founded on a supposed continuation of those lines of equal quantities, whose tendency has been already ascertained in the surrounding seas."

Before we pass to what has been done in the mainland of Africa for the study of the magnetic state of the continent, it may be as well to give a short account of the stage magnetic cartography of land areas has reached, and to what extent a magnetic map represents the results of observations. The charts so far put before you show beautifully rounded lines, which enable us to see at a glance what the value of a particular element, such as the declination, ought to be at any given place at the epoch for which the map is drawn; the magnetic maps giving the results of the earliest surveys in European and American countries have the same flat and regular appearance. As, however, the number of stations at which observations were made was increased it became apparent that the magnetic

* Hellmann: Magnetische Kartographie Veröffentlichungen des Königlichen Preussischen Meteorologischen Instituts. Abh. Bd. III., No. 3. Berlin, 1909.

† The writer is indebted to Dr. Flint for permission to photograph the copy of this chart contained in the Parliamentary Library.

elements did not vary from place to place in any regular predictable manner. The hope that irregularities would disappear as the observations became more exact has had to be given up, and at the present day we may be quite certain—to quote Bauer:

—"When you see perfectly regular or smoothly flowing lines you may rest assured that they have been either smoothed out or that they depend upon but very few data. Instead of the irregularities being the abnormal features, they are the normal ones, and regularities are, in fact, the abnormal features."

The results of Thorpe and Rücker's* work in the British Isles, and of Carlheim Gyllensköld's † in Sweden, first brought before magneticians the extremely irregular character of isomagnetic lines reproducing the values of magnetic elements at a given epoch. One of the first effects of the clear perception of this was the introduction of suitable names for the different kinds of lines. At the present day it is customary to speak of true isomagnetics, in which all the observations—after suitable reduction to the epoch—are taken into consideration, and terrestrial isomagnetics derived from the former, either by calculation or by a graphical method; these are to a great extent ideal, and depend on the method of production. The maps which are now thrown on the screen show the increase in complexity due to a more intensive survey; the first gives the isogonics for France (epoch 1885), from observations at 80 stations; the second gives the isogonics for the same country (1896) from observations at 617 stations; the third map shows the true and the terrestrial isogonics for Great Britain (epoch 1886).

After a survey, with the stations as numerous as in Moureaux's second survey of France, or Rücker and Thorpe's surveys of the British Isles, the magnetic state of the region under consideration can be further studied. One of the best known methods of doing this is by the method of districts, first used by Dr. van Rijckevorsel,‡ and fully developed by Rücker and Thorpe.§ The two latter observers divided the British Isles into nine districts, and obtained for each of these a mean station by taking the means of the latitudes and the longitudes of all the stations in a given district. The value of any magnetic element at such a station was obtained in a similar manner. In this way nine mean stations were determined, each with its own mean values for the different magnetic elements. General formulæ, expressing the value of an element as a function of the latitude and the longitude, were then constructed, reproducing the values of that element at the mean stations; from such formulæ the terrestrial isomagnetics were derived. Once a suitable formula of the above nature has

* Philosophical Transactions, Series A, Vol. 181, p. 53, Survey of the British Isles for the epoch Jan. 1, 1886. Rücker and Thorpe. London, 1891.

† Mémoire sur le magnétisme terrestre dans la Suede meridionale par C. Gyllensköld Kongl. Svenska Vetenskaps-Akademiens Handlingar. Bandet 27, N: 07. Stockholm, 1895.

‡ Report on a Magnetic Survey of the Indian Archipelago, by Dr. van Rijckevorsel. Part I., p. 17. J. Muller, Amsterdam, 1879.

§ Phil. Trans. *Loc. cit.*

been found it is possible, by substituting in it the geographical co-ordinates of an actual station, to calculate the value a given element—say, the declination—ought to have. These calculated values represent the magnetism due to the most likely mean field, as derived from the observations; if such values are then subtracted from the actually observed values we have a residual effect, which may reasonably be attributed to the special magnetic features of the country. I need scarcely point out to you how cautiously one must proceed in any deductions of this nature. We have only to consider how many corrections have to be applied to the observational results, and how inexact the knowledge of these is, even in countries where the magnetic elements have been the subject of study ever since Gauss's time. The method of districts has also been used by Mathias.* He has taken the mean results of the nine districts derived by Thorpe and Rücker for the British Isles, and has by the method of least squares obtained formulæ which reproduce the results at these mean places with a degree of accuracy as great as that given by the general formulæ of the original workers; his residual field is also practically identical with theirs.

The systematic use of the forms of isomagnetic lines in larger surveys has been of very recent introduction; in the case of smaller surveys, however, the value of the lines for the discovery and subsequent survey of ironstone masses has been long recognised in Sweden and in America. Even in cases where the surface gives no indication of the existence of iron ore, deposits have been discovered by the use of the magnet. In Sweden it is almost universally the custom to make a magnetic map of every iron mine, and by help of this to show where shafts ought to be sunk, levels driven, and development pushed forward. An example of this is a plan of the great ore deposits in Swedish Lapland, showing not only the outcrops, but the non-exposed extensions of the ore-mass, whose position had been determined by magnetic surveying.† The magnet has also been used as an iron-ore finder in America; in some parts over 50 per cent. of the new iron mines have been discovered in this way. Curiously enough, the idea seems at one time to have been prevalent that magnetic methods for finding iron ore could not be used in lower latitudes. Professor Nordenström‡ called attention to this belief, and disposed of it by himself applying the method in Spain, and showing that it was quite as efficacious there as in Sweden itself. The results obtained with the magnet as an ore-finder are to the more ignorant so astonishing that many of the marvels attributed to the divining-rod have been transferred to the compass needle, and the attempts at explaining the result by the ordinary prospector are quite as fanciful as anything a water-finder can

* Annales de l'Observatoire Astronomique, Magnétique et Météorologique de Toulouse, T. 7. Recherches sur le Magnétisme terrestre par E. Mathias. Paris, 1907.

† Terrestrial Mag., Vol. IV., p. 276. Baltimore, 1899.

‡ Journal of the Iron and Steel Institute, II., page 55, 1898.

evolve. The similarity between the two does not end there; fraud is practised with one as much as with the other, and in the case of the iron ore prospector it is not unusual to find that the behaviour of the magnet is different according as the user is a buyer or a seller.

When we come to consider South African magnetic surveys, the first thing that strikes our attention is the late period at which such surveys have been begun. We have already seen from Rennell's note what was known at the end of the eighteenth century. In a summary of available magnetic data for the various continents given in the introduction to Berghaus's "Atlas des Erdmagnetismus,"* we find, as late as 1891, Neumayer pointing out that over the whole of this vast continent observations had been made at only a few places on the coast; that the magnetic state of the interior was quite unknown, and that so long as such a state of affairs continued it was impossible to undertake a thorough study of the earth's magnetic state. At that time the only magnetic results for places in the interior of Africa were those due to Capello and Ivens. These two travellers started from Loanda, in Portuguese West Africa, in September, 1877, and after spending a little over two years, chiefly in Angola, returned to Loanda in October, 1879. In the account† of their journey, published in Lisbon in 1881, magnetic charts‡ are given which show the declination, the dip, and the total intensity. The epoch is 1879, and the charts include the regions between 6° and 16° South latitude, and between 12° and 20° East longitude. The lines are quite flat and regular. How they were obtained I have not been able to find out. The same two travellers made a second journey in Africa during 1884 and 1885. An account§ of this was published in Lisbon in 1886, and it contains the results of observations at 23 stations, extending from Mossamedes on the west, through Angola and North-Western Rhodesia to Tete on the Zambesi.

The first extended survey in Africa south of the equator was carried out in the Congo territories. The observers were Delport and Gillis,‖ who worked together in 1890 along the lower reaches of the Congo and Lemaire,¶ who made two journeys, one from 1898 to 1900 in the Katanga district and along the west shores of Lake Tanganyika. On this journey he observed at 120 stations; in his other journey** Lemaire went from the Congo to the Nile in 1902 to 1904, when he occupied another 35 stations. Unfortunately, in all these Congo expe-

* Atlas des Erdmagnetismus, S. 4, Berghaus Physikalisches Altas, Abt. IV. Gotha, 1891.

† De Benguella as Terras de Iacca. Capello and Ivens, Lisbon, 1881.

‡ Hellmann, *Loc. cit.*

§ De Angola a contra Costa. Capello and Ivens, Lisbon, 1886.

‖ Observations Astronomiques et Magnétiques executées sur le territoire de l'Etat Independant du Congo, Mémoires Couronnés Tome LIII. L'Academie Royal des Sciences, Brussels, 1893-1894.

¶ Mission Scientique du Katanga. Lemaire, Publications de l'Etat Independant du Congo, Brussels, 1901.

** Mission Scientifique du Congo-Nil. Lemaire, Public. de l'Etat Independant du Congo, Brussels, 1905.

ditions the instruments and the methods used for the determination of the dip and the horizontal intensity were unsatisfactory, and the values obtained for these elements can scarcely be looked upon as anything but rough approximations to the true results.* On the other hand, the declination results obtained are satisfactory, and enable us to form a good idea of the value of that element in Central Africa. None of these observers has published a magnetic map of the Congo. Keeling has used their results, however, to give the terrestrial lines in his magnetic maps of Northern Africa.

In Africa, south of the Zambesi, a considerable amount of magnetic work has been carried out in recent years, chiefly by Beattie and Morrison. Between 1898 and 1906 observations were carried out at over 400 stations, several of which were occupied more than once for the purpose of determining the secular variations of the various elements. The results at these repeat stations have already been mentioned. The observations were reduced to the epoch July 1st, 1903, and magnetic charts have been published† giving the true isomagnetics for the surveyed regions at that date. Like all charts representing the results of a survey of this density, they show many irregularities. The disturbances are greater in the Transvaal than in any other part; a glance at any of the charts shows, however, that there are other very disturbed regions, and the fact that in many districts the lines appear less convoluted is probably due to the number of stations there being fewer. The maps which I have now to show you give, in addition to the true isomagnetics, the terrestrial also. In determining the latter, the observations made in Southern Rhodesia and in Bechuanaland were not used; the stations in the other parts of South Africa were divided into 15 districts, and a mean station obtained for each, with mean values for the declination, the dip, and the horizontal intensity. By the method of least squares a suitable formula was obtained for each of the three elements, and by help of these the terrestrial lines have been drawn.‡ I might go on to give you details of the residual magnetic field in this part of South Africa. This, however, would lead me too far, and I shall content myself by referring you to the published report of this survey.

To complete the account of magnetic work in this part of the world I have still to mention the observations carried out in German East Africa by Maurer,§ those in Madagascar by Colin,‖ the work carried out by Chaves,¶ and the observations by Beattie and Morrison in 1909**, when over 300 new stations

* Magnetic Observations in Egypt, 1895-1905, with a summary of previous magnetic work in Northern Africa, by B. F. E. Keeling. Survey Department Paper No. 6. Cairo, 1907.

† Report of a magnetic survey of South Africa, by J. C. Beattie. Royal Society, London, 1909.

‡ See Appendix to this Address.

§ Keeling, *loc. cit.*

‖ Terrestrial Magnetism, Vol. VIII., p. 187.

¶ Contribution aux études de magnétisme terrestre en Afrique, par F. A. Chaves. Bulletin de l'Institut Oceanographique, Monaco, 1908.

** The funds for this expedition were provided by the Carnegie Institution of Washington, supplemented by grants from the London Royal Society, and from Sir Lewis Michell and Dr. Jameson.

were occupied in different parts of Africa, chiefly in the Cape Colony, German South-West Africa, North-Western and North-Eastern Rhodesia, British Central Africa, Portuguese East Africa, German East Africa, British East Africa, and Uganda.

It is evident that the knowledge of the magnetic state of our part of Africa has been considerably increased since 1890, a remark which also applies to North Africa, particularly to Egypt. We must not, however, rest yet. A glance at the accompanying map, which shows by a network of lines the regions magnetically studied, lets us see that even in South Africa there are still great tracts whose magnetic state is a matter of conjecture. I need only mention the Kalahari, the greater part of the Rhodesias, the western part of the continent from Windhuk up to the Congo mouth, the greater part of Portuguese East Africa, German East Africa, and British East Africa. Magneticians must also keep in view the establishment of one or more permanent stations; indeed, at the present day probably that is more essential for the thorough magnetic study of South Africa than anything else.

APPENDIX.

Terrestrial lines for declination, dip, and horizontal intensity for South Africa.

The data used for calculating these lines are taken from the Report of a magnetic survey of South Africa already referred to. The stations in the Cape Province, Orange Free State, Natal, and Transvaal were divided into 15 districts and a mean station obtained for each district in the manner there described. Station No. XI. was taken as the reference station, and a table, No. 3, formed, in which are given the differences in latitude ($\Delta\phi$), longitude ($\Delta\lambda$), declination (ΔD), dip ($\Delta\theta$), and horizontal intensity (ΔH) of the different mean stations from the reference station.

Table No. 3.

District.	$\Delta\lambda$	$\Delta\phi$	ΔD	$\Delta\theta$	ΔH (γ)
I.	−435′	+248′	+213′	−28′	−197
II	−323′	+252′	+203′	+19′	−394
III.	−192′	+238′	+172′	+57′	−554
IV.	−71′	+227′	+134′	+90′	−695
V.	+140′	+121′	+23′	+102′	−591
VI.	+259′	+5′	−75′	+82′	−304
VII.	+231′	−116′	−145′	−7′	+322
VIII.	+97′	−101′	−87′	−30′	+357
IX.	+242′	−219′	−211′	−69′	+858
X.	+104′	−183′	−128′	−73′	+703
XII.	−53′	+120′	+77′	+44′	−344
XIII.	−281′	+140′	+141′	−20′	−120
XIV.	−252′	+48′	+96′	−57′	+115
XV.	+212′	−345′	−274′	−161′	+1485

With these differences an equation of the form

$$\Delta\ (\text{mag. elem.}) = a + b\,\Delta\lambda + c\,\Delta\phi + d\,(\Delta\lambda)^2 + e\,\Delta\lambda\,\Delta\phi + f\,(\Delta\phi)^2$$

was formed. The three equations* obtained in this way are :—

$$\Delta D_c = -\cdot 02199 - \cdot 30726\,\Delta\lambda + \cdot 52533\,\Delta\phi - \cdot 0_4882\,(\Delta\lambda)^2 + \cdot 0_32966\,\Delta\lambda\,\Delta\phi - \cdot 0_4264\,(\Delta\phi)^2.$$

$$\Delta\theta_c = -\cdot 00779 + \cdot 30128\,\Delta\lambda + \cdot 55247\,\Delta\phi - \cdot 0_4564\,(\Delta\lambda)^2 + \cdot 0_4838\,\Delta\lambda\,\Delta\phi - \cdot 0_32003\,(\Delta\phi)^2.$$

$$\Delta H_c = + \cdot 28615 - 1\cdot 01442\,\Delta\lambda - 3\cdot 94215\,\Delta\phi - \cdot 0_32107\,(\Delta\lambda)^2 - \cdot 00254\,\Delta\lambda\,\Delta\phi + \cdot 001151\,(\Delta\phi)^2.$$

From these equations the calculated values D_c, θ_c, and H_c were found for the respective mean stations and the differences $D_c - D$ taken.

The results are shown in

TABLE No. 4.

District.	$D_c - D$	$\theta_c - \theta$	$H_c - H$ (γ)
I.	+ 2′	+ 1′	— 6
II.	— 5′	— 4′	+ 16
III.	— 5′	— 2′	+ 13
IV.	+ 3′	+ 2′	0
V.	+ 3′	+ 3′	— 29
VI.	— 6′	— 6′	+ 33
VII.	+ 2′	+ 4′	+ 4
VIII.	+ 2′	— 2′	+ 7
IX.	+ 2′	+ 3′	— 34
X.	— 6′	— 6′	+ 26
XII.	+ 2′	+ 1′	— 14
XIII.	+ 1′	0	— 12
XIV.	— 2′	+ 2′	+ 2
XV.	+ 1′	0	+ 3

Finally, Table 5 gives the calculated values for the declination, the dip, and the horizontal intensity, at the intersections of alternate whole degrees of latitude and of longitude. From these figures the respective terrestrial lines have been plotted. Maps 1, 2, and 3.

TABLE No. 5.

λ	ϕ	D_c	θ_c	H_c (γ)
18° E.	34° S.	28° 47′ W.	59° 2′ S.	18253
20° ,,	34° ,,	28° 30′ ,,	59° 47′ ,,	18073
22° ,,	34° ,,	28° 8′ ,,	60° 30′ ,,	17887
24° ,,	34° ,,	27° 45′ ,,	61° 11′ ,,	17695
26° ,,	34° ,,	27° 19′ ,,	61° 51′ ,,	17497
18° ,,	32° ,,	28° 3′ ,,	58° 11′ ,,	18520
20° ,,	32° ,,	27° 42′ ,,	58° 54′ ,,	18377
22° ,,	32° ,,	27° 14′ ,,	59° 36′ ,,	18228
24° ,,	32° ,,	26° 47′ ,,	60° 16′ ,,	18072

* I have to thank Mr. Whittingdale of the Royal Observatory of the Cape of Good Hope for carrying out the necessary calculations.

λ	ϕ	D_c	θ_c	H_c
				γ
26° ,,	32° ,,	26° 16′ ,,	60° 55′ ,,	17911
28° ,,	32° ,,	25° 43′ ,,	61° 32′ ,,	17743
18° ,,	30° ,,	27° 18′ ,,	57° 13′ ,,	18820
20° ,,	30° ,,	26° 52′ ,,	57° 55′ ,,	18714
22° ,,	30° ,,	26° 22′ ,,	56° 36′ ,,	18601
24° ,,	30° ,,	25° 50′ ,,	59° 15′ ,,	18482
26° ,,	30° ,,	25° 15′ ,,	59° 52′ ,,	18358
28° ,,	30° ,,	24° 38′ ,,	60° 28′ ,,	18227
30° ,,	30° ,,	23° 58′ ,,	61° 2′ ,,	18090
18° ,,	28° ,,	26° 32′ ,,	56° 10′ ,,	19154
20° ,,	28° ,,	26° 2′ ,,	56° 51′ ,,	19084
22° ,,	28° ,,	25° 27′ ,,	57° 30′ ,,	19008
24° ,,	28° ,,	24° 51′ ,,	58° 8′ ,,	18926
26° ,,	28° ,,	24° 12′ ,,	58° 44′ ,,	18838
28° ,,	28° ,,	23° 31′ ,,	59° 19′ ,,	18743
30° ,,	28° ,,	22° 48′ ,,	59° 52′ ,,	18643
18° ,,	26° ,,	25° 46′ ,,	55° 1′ ,,	19521
20° ,,	26° ,,	25° 11′ ,,	55° 41′ ,,	19487
22° ,,	26° ,,	24° 32′ ,,	56° 19′ ,,	19448
24° ,,	26° ,,	23° 52′ ,,	56° 56′ ,,	19402
26° ,,	26° ,,	23° 9′ ,,	57° 31′ ,,	19351
28° ,,	26° ,,	22° 23′ ,,	58° 4′ ,,	19293
30° ,,	26° ,,	21° 35′ ,,	58° 35′ ,,	19229
32° ,,	26° ,,	20° 44′ ,,	59° 5′ ,,	19159
26° ,,	24° ,,	22° 4′ ,,	56° 11′ ,,	19909
28° ,,	24° ,,	21° 24′ ,,	56° 43′ ,,	19888
30° ,,	24° ,,	20° 22′ ,,	57° 14′ ,,	19861
32° ,,	24° ,,	19° 27′ ,,	57° 43′ ,,	19828
26° ,,	22° ,,	20° 58′ ,,	54° 46′ ,,	20476
28° ,,	22° ,,	20° 5′ ,,	55° 17′ ,,	20491
30° ,,	22° ,,	19° 8′ ,,	55° 46′ ,,	20501
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CHART I.

TRUE AND TERRESTRIAL

ISOCLINALS

1st JULY, 1903.

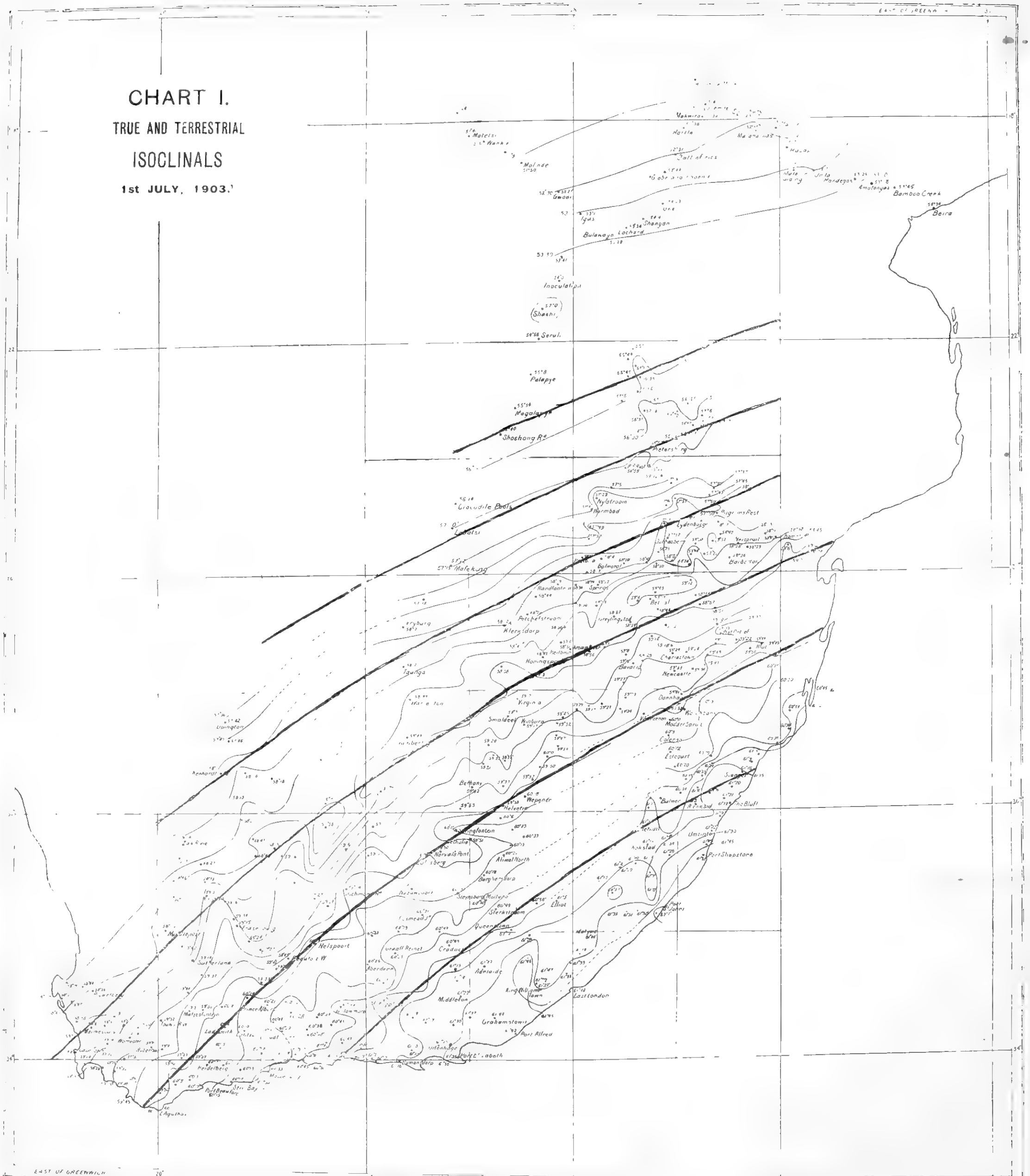


CHART II.

TRUE AND TERRESTRIAL

LINES

OF

EQUAL HORIZONTAL INTENSITY

1st JULY, 1903.

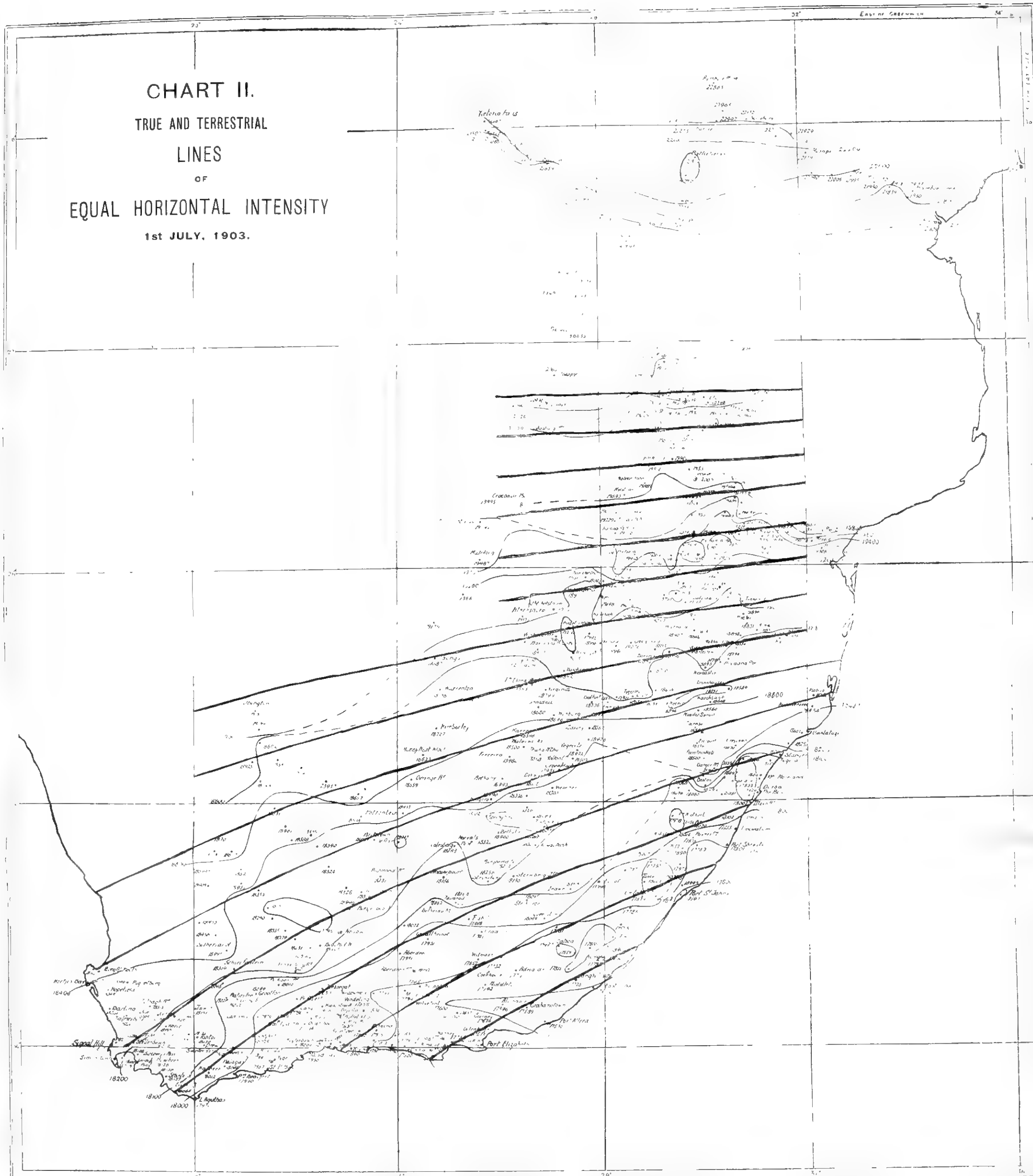
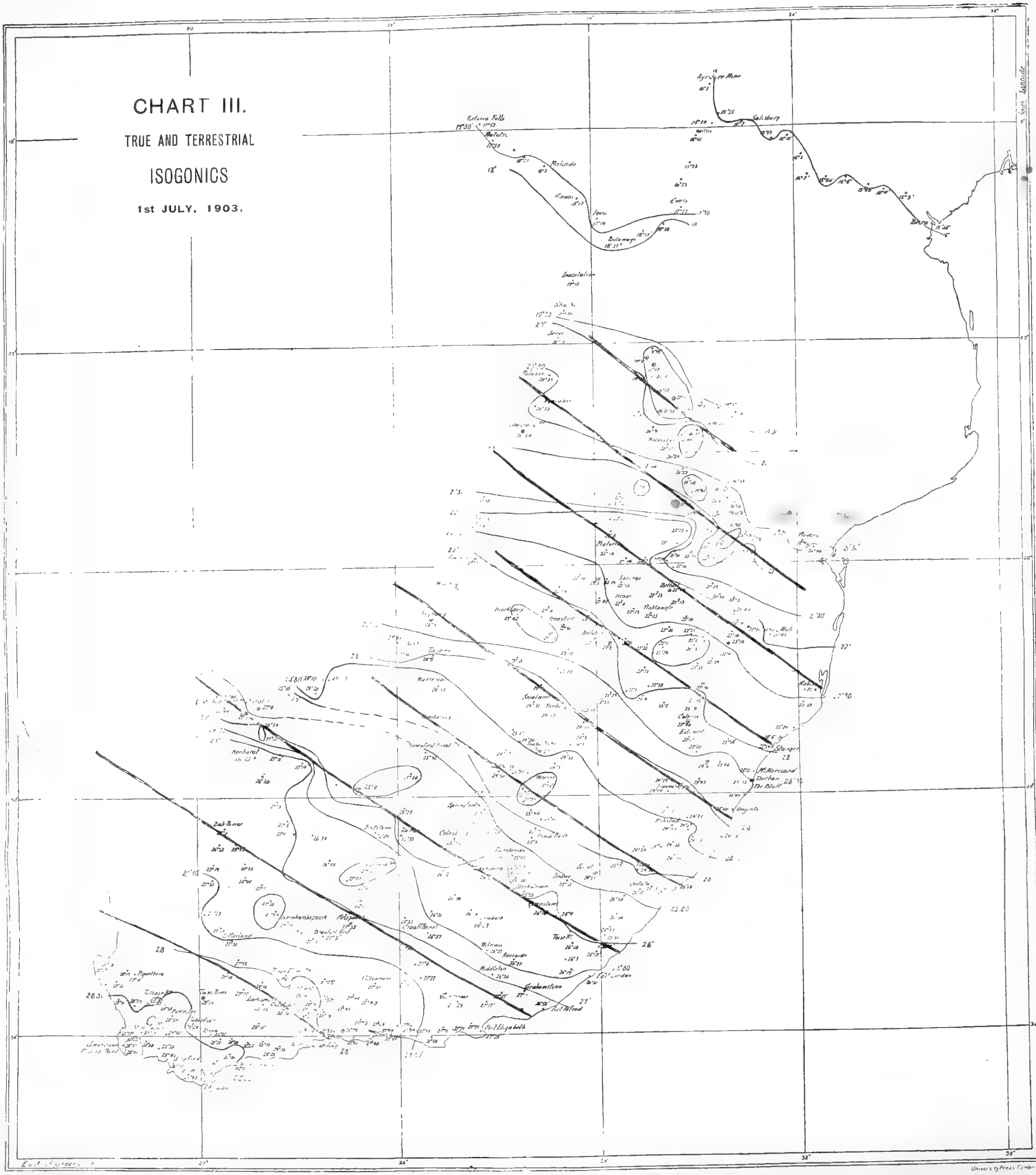


CHART III.

TRUE AND TERRESTRIAL

ISOGONICS

1st JULY, 1903.



Section B.—CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.

President of the Section—A. W. Rogers, M.A., Sc.D., F.G.S.

TUESDAY, NOVEMBER 1.

The President delivered the following address:—

"In examining things present, we have data from which to reason with regard to what has been; and from what has actually been, we have data for concluding with regard to that which is to happen hereafter. Therefore, upon the supposition that the operations of nature are equable and steady, we find, in natural appearances, reasons for concluding a certain portion of time to have necessarily elapsed, in the production of those events of which we see the effects."

So wrote James Hutton on an early page of his "Theory of the Earth," which was published in 1785. That passage, and others to the same purpose, clearly prove the speculative character of the geological discussions of the time; otherwise the method alluded to, which is the only one by which geology can get a firm foundation, would not have required statement in such a categorical form.

Of all the sciences there is perhaps none in which speculation can more readily run riot than geology, because it is so difficult to reconstruct in imagination all the circumstances which govern any particular event recorded in the rocks. The fashion, therefore, of working on uniformitarian lines that was set by Hutton, and followed with such success by Lyell, was of the greatest service to geology, even though it was attended by the conspicuous disadvantage of suppressing enquiry into things which, by their nature, could not be explained by processes open to observation.

The essence of the uniformitarian theory is that only those agencies which are known to be efficaceous in bringing about changes in the earth's crust or on its surface can be called upon to explain the meaning of the rocks. It is obvious that every discovery which extends our knowledge of processes going on upon the earth, in it, and outside it, if they affect the crust or its surface, must come within the province of the theory. An important assumption made by Hutton was that throughout past times, of which we have records in the rocks, the agencies at work to-day have not varied greatly from their present scale of activity; it is this part of the theory that has met with most opposition.

It is my purpose on this occasion to review some of the results of geological work done in South Africa bearing on the origin of certain very old rocks, the history of vulcanism, and past climates, with the object of discovering whether they necessitate any serious modifications of the uniformitarian theory.

One of the most interesting questions in geology concerns the origin of the rocks often called Archæan. They are schistose and foliated rocks with a chemical composition comparable with that of sedimentary and igneous rocks, but their minute

structure is not like that of ordinary sediments, lavas and intrusive rocks, and they are very old. Such rocks are found over a large part of South Africa, and though they have received some attention, they have not been so closely investigated as analogous rocks in Europe and North America.

There is no body of rock in this country which has been shown to be older than the oldest recognisable sediments. The great areas of gneiss and granite in the north and north-west of Cape Colony, Rhodesia, the Transvaal and Natal, contain streaks and blocks of other material, which, from its mineral composition and the structures met with in it, was once either sediment derived from rocks older than itself, and consequently much older than the igneous rocks which envelope it, or volcanic rock poured out on the surface of the earth. In certain cases there are transitions, in one group of outcrops, from rocks that are clearly of volcanic origin to others in which the original volcanic nature is only recognisable owing to the preservation of lumps of quartz and other minerals that represent the amygdales of the formerly vesicular lava. The present minute structure of these rocks is absolutely different from that of any unaltered lavas, but is like that of schists and granulites frequently met with in Archæan areas in many parts of the world. Usually the different stages through which the rocks have passed in reaching their present condition cannot be seen in one and the same group of outcrops, but from the observed instances of transitional rocks the origin of some of the extreme results of change can be understood.

In order to understand the relationships of many of those highly metamorphosed rocks as seen in the field it appears to be necessary to assume that absorption of the rocks invaded by the once liquid granite has taken place on a large scale; yet, with the exception of a few comparatively small bodies of rock with the structure of granite but having a mineral and chemical composition very different from that of a normal granite or other igneous rock, it is exceedingly difficult to point to the only convincing class of evidence, that is, the existence on an appropriately large scale of rocks with a composition that removes them from the ordinary igneous rocks, while in structure they belong to the latter.

From the nature of the case direct proof of the complete cycle from a volcanic rock, through the various stages of conversion into schists and granulites, and the return to conditions which may result in its reappearance as an igneous rock can never be obtained. Yet from a study of the intensely changed volcanic rocks of Kenhardt and Prieska it is clear that a slight effort will unable one to complete the cycle in imagination. If, however, the additional stages due to the selective action of the various processes of weathering and deposition at the earth's surface be introduced into the cycle, the following up of the process becomes much more difficult, even in imagination, owing to the necessity of providing for the renewal of the more easily eliminated substances, such as the alkalies, and the distribution of the accumulated alumina.

That some of the metamorphic rocks of Prieska and Kenhardt were volcanic rocks allied to basalt is shewn by the preservation of their amygdales and the mineral composition of the bulk of the rock, even in cases where there is no resemblance to basalt in the minute structure. The usual relations of the felspar, augite and metallic ores in lavas have been replaced by a granular structure in which no priority of formation can be made out in favour of any one group of minerals, though the changes in the nature of the minerals themselves have probably been slight. Though the transitional stages are known in certain groups of outcrops, they have not been traced in one and the same lava-flow. Whether this can be done remains for further work to prove.

It is evident from the detailed examination of these rocks that the transference of material from one part to another of the same mass, or from one rock to another, has often been extremely limited, but the proof of an extensive interchange, or diffusion, could only be got by a much more detailed research in the region than has yet been attempted. The indications of such a process are given by the massive or foliated granitic rocks which contain large quantities of the magnesian and aluminous silicates not found in the normal granite and gneiss. Such rocks are found in Kenhardt and Prieska, and they can be looked upon as the result of the solution of sediments of a magma which would have solidified as granite or gneiss had it not dissolved the sediments.

The possible courses taken in the averaging of a large bulk of sediments, lavas and the magma which carried with it the means of bringing them to the liquid state, and the possible re-differentiation of the resulting mixture, are beyond my powers to follow; and it will be sufficient to point out one circumstance which raises doubt as to the actuality of the process. The inevitable result of the great changes at the surface which bring about the formation of various kinds of sediments at the expense of igneous rocks is to separate the more soluble from the less soluble constituents of the latter, and therefore during past times the alkaline constituents have been stored up in the ocean. The sediments available for a possible melting up and re-issue as lava or intrusive rocks must have suffered an impoverishment in alkalies, so we should expect, on the supposition that such cycles of change are restricted to a comparatively thin layer below the surface, that the later igneous rock would contain distinctly less alkalies than the earlier, yet no evidence of this has been discovered.

One of the most important discoveries yet to be made in South African geology is the position in the stratigraphical succession of the equivalent of the Cambrian system of other continents. Until Cambrian beds are recognised there can be no thorough comparison of the ancient rocks with the Pre-Cambrian of other countries. We only know that the ancient rock-systems of the north, which may perhaps be of Pre-Cambrian age, must represent an enormous lapse of time, and

that here no evidence has been found of a time when sediments first began to form on the earth's surface. The most ancient rocks here are sediments of several kinds, including limestones, and volcanic flows, which, allowing for the alteration they have undergone, are of the same nature as rocks formed in modern times. Then, as now, the predominant source of sand and clay was granite; the débris was not always broken up into sand and clay, for thick beds of quartz-felspar grit were formed. The lime and magnesia furnished by the weathering of rocks were to a large extent separated from the siliceous and aluminous parts of the rocks and laid down as beds of limestone, whether by organisms or not can only be judged by analogy with younger limestones. The action of air and moisture, wind and waves, may have been of about the same order in those days as now, for all that we can determine from the records preserved in the rocks.

It must be granted that the precise significance of ancient sedimentary rocks, which do not contain fossils, as to the climatic conditions under which they were formed, is exceedingly difficult to understand, but in the case of volcanic rocks comparison with their modern analogues can be made on more favourable terms.

There are at present no active volcanoes in South Africa, but in the past this sub-continent has had its share of them, as is the case with many other regions where there are none now. But although the location of volcanic activity has changed, a brief survey of the ancient volcanic rocks of the country and a comparison with those of other countries will enable us to form an opinion as to whether there is any reason to believe that there has been a regular decline in vulcanicity during the time represented by our rocks.

Some of the earliest South African lavas yet recognised are those of the Kheis series in Prieska, Kenhardt, and Gordonia. There are probably two groups of them, one at the bottom and one at the top of that formation. They are greatly altered in texture from their original condition, but both basic and acid lavas have been found in them, as well as beds of breccia and tuff thrown out from the volcanoes, or derived from the subaerial destruction of lava. The true thickness of these rocks has not been estimated, but they may be no more than some 5,000 feet. The area they originally covered must have been considerable, not less than 10,000 square miles, but at present there is no information beyond this limit. Up to the present time these and similar, possibly equivalent, lavas of the Kraaipan beds, Bechuanaland, are the only volcanic rocks older than the granite of Kenhardt, and also older than the Ventersdorp system, that have been described from Cape Colony, though the thick sediments of the Malmesbury series are known superficially over a wide area in the south.

The next great period of activity is represented by the lavas of the Ventersdorp system, which, however, were very widely separated in time from those just mentioned; the irruption of

vast bodies of granite, probably mountain building, and certainly a prolonged period of denudation intervened between the two, but with the exception of the Witwatersrand formation, which consists of detrital sediments, the interval is apparently unrepresented by rocks in South Africa. The Ventersdorp formation and its possible correlative, the Koras series near the Orange River in Gordonia and Kenhardt, occur over an area more than 70,000 square miles in extent, though the continuity of the group is broken by denudation and concealment under newer rocks, and probably was never complete over the whole area. The total thickness of the volcanic rocks and sediments of the Ventersdorp series is considerable, but it varies greatly in different districts.

The Transvaal system has near its base in Vryburg an insignificant thickness of volcanic rocks closely resembling the more basic of the Ventersdorp lavas, and a much more important group of lavas of intermediate composition on a higher horizon, the Ongeluk lavas of Griqualand West and Bechuanaland, and the probably corresponding lavas in the Pretoria series of the Transvaal. It is possible that these volcanic rocks had a distribution as wide as that of the Ventersdorp lavas.

There is a considerable gap between the latest known rocks of the Transvaal system and the earliest Matsap beds. Without prejudice to the doubtful correlation questions affecting the Waterberg and Matsap series, it will be sufficient for the present purpose to point out that lavas exist in both those formations; in Bechuanaland the total thickness of volcanic rocks is less than 1,000 feet, but in the Middelburg district (Transvaal) the Waterberg volcanic rocks are nearly 8,000 feet thick.

Throughout the period represented by the Cape formation (assuming for the moment that the Matsap and Waterberg are not the equivalents of the Table Mountain series) and the greater part of the Karroo system, that is from Silurian to early Jurassic times, there were apparently no volcanic outbursts in South Africa; but in the Jurassic period, which in Europe and North America was remarkable in being free from volcanic activity, there came what may be regarded as the greatest of all the recorded South African volcanic outbursts. From the Transkei to beyond Nyasa there are large areas of basic lavas which are associated with and follow the youngest Karroo deposits. In Natal they reach 5,000 feet in thickness. These rocks, called the Drakensberg group in the south, are remnants of their former selves, for they have lost much by denudation. The area affected by volcanic activity at this period was probably very much larger than that covered by the surviving lavas, for there is good reason to connect with it the basic intrusions that are so characteristic of the Karroo region.

The latest phrase of volcanic activity in South Africa left its traces in the pipes and dykes filled with melilite-basalt, kimberlite, various other breccias, and lamprophyres of late Cre-

taceous or Tertiary times, but it apparently gave rise to no superficial flows that have survived to the present day.

There are several striking points of difference between this history of vulcanism in South Africa and that recorded in the northern hemisphere. Setting aside possible equivalents of the earlier Palæozoic volcanic rocks of Europe and North America, we find nothing to compare with the later Palæozoic and early Mesozoic volcanic rocks of those regions, nor again with the late Cretaceous and Teritary flows of India, nor with the immense Tertiary flows of north-west Europe and western America.

It is by no means evident that South Africa was the scene of more intense or more wide-spread vulcanicity in early times than in later, and it seems very probable that we have no record of greater activity than that which still persists in the Hawaiian island, Iceland and the Central States of America. It is not alone the positive evidence which bears out this opinion; the negative is of almost equal importance; for the great thicknesses of ancient rocks in the Malmesbury, Ibiquas and Cango beds in the south and west, and in the Witwatersrand beds of the north, have not yet yielded definite evidences of contemporaneous igneous rocks.

South Africa brings no support to the view that the earth's volcanic activity has declined, steadily or irregularly, from the earliest times of which we have knowledge; the present quiescence in this region may be merely temporary; it has certainly not endured so long as the period referred to above, which lasted from Silurian to Jurassic times.

Of the varieties of climate which affect the earth's surface to-day none leaves such characteristic traces as a glacial climate. Tropical, temperate and desert conditions are accompanied each by its characteristic processes of change at the surface, but though these are becoming better understood year by year, yet the results of this knowledge can at present only be applied with difficulty and to a very limited extent to the stratified rocks, partly because ancient land surfaces and the deposits formed on them have rarely been preserved. But a glacial climate leaves more enduring marks, both on the upland surface and in the deposits formed on low ground and near the coast.

No satisfactory explanation other than that afforded by the assumption of glacial conditions has been put forward to explain the peculiarities of such rocks as the boulder beds of the Dwyka series. Many years passed between the first recognition of the meaning of these rocks in India and South Africa and the general acceptance of the evidence by European and American geologists; even as lately as 1906 the opinion was expressed in a geological treatise of the first rank that

"in fact all proof of a glacial temperature is wanting in the ancient periods of the globe, and in spite of the complaisance with which several geologists have admitted . . . . the existence of Silurian or even Cambrian glaciers, we do not believe that any naturalist subscribes to an hypotheses in formal discord alike with the conditions of relief in those days and the existence of corals in all the Palæozoic seas."

This dogmatic statement could hardly have been made had its author been able to investigate the facts for himself, but as it unfortunately happens that the evidence so far discovered lies in rather remote regions—India, China, Australia, South Africa, Norway, Canada, South America—preconceived notions of what ought to have been have prevented the acceptance of evidence quite as good as that which leads men to believe that anthracite is of vegetable origin.

South Africa has, so far as we know at present, a fuller record of glacial periods than any other part of the world, for on three distinct horizons there is good evidence of glacial conditions. The earliest, that in the Lower Griqua Town beds, is a tillite with striated boulders, which is nearly 100 feet thick in places and extends from the Orange River to Madebing in Bechuanaland. Unfortunately we are at present in ignorance as to its age, and beyond saying that it must be older than the Devonian nothing definite can be stated. The evidence for the second glacial period is very restricted at present, being confined to a strip of country about 23 miles long in Clanwilliam, with a probable outlier on the top of Table Mountain. This evidence is also in the form of a tillite and striated boulders, probably of late Silurian age. The third period is represented by the Dwyka tillite known in all the territories south of the Zambesi, and the underlying glaciated surfaces north of the Karroo. This glaciation occurred in late Carboniferous, or possibly early Permian times, and corresponding rocks, which may well be considered contemporaneous with our Dwyka, are known in India, Australia, and South America.

The question of the cause of this remarkable extension of glacial conditions in low latitudes has not been solved, though several attempts have been made. The facts are now fairly well known, and the glacial explanation is generally accepted. Their importance for our present purpose is that they negative the view that a gradual change of climate in one direction has prevailed; there was, as far back as we can trace the evidence, no universal climate, warm or otherwise, out of which the climatic zones of to-day have developed. The cold conditions have been ascribed to two sets of causes; alteration in the composition of the atmosphere, by which less hindrance was placed in the way of the escape into space of the dark heat-rays from the earth's surface, and changes in the amount or nature of the rays received from the sun. It has been shown by observation that the heat received from the sun alters in amount within comparatively short periods, and also that a variation in the quantity of carbon dioxide in the air must affect the air's power of preventing the escape of heat; but the great difficulty in the way of these explanations is that they must apply to the whole surface of the earth, while the glacial condition were, so far as is known, confined to certain areas. For instance, if any such hypothesis be put forward to explain the Pleistocene glaciation, a difficulty arises from the fact that no sign of glacial conditions in those times has been discovered

in South Africa. Though exceptions of this kind may be attributed to the effect of geographical conditions in influencing the oceanic and air currents, the details are exceedingly difficult to ascertain and support by evidence.

The conclusion which may be drawn from this brief consideration of the evidence from South African geology in the three questions chosen is that though this part of the globe has experienced great changes since the earliest known sediments were laid down, yet those changes have not been uniform in direction. While the activity of any one agent of change, such as vulcanism, has been great at certain times and dormant at others, it has possibly at no time surpassed the degree it attains in some quarters of the globe to-day.

The uniformitarian theory has been a very good servant to geology in checking excesses, and the opposition to it has probably in all cases risen from the arguments put forward by astronomers and physicists, who, by starting from a state of things observed in other parts of the universe or reached by retracing the steps indicated by the present relation of earth, moon and sun, have shown that there must have been a time when circumstances on the earth's surface were very different from what they are now. It is obvious that geology must provide the criteria by which alone these theories can be judged, so far as they concern the period represented by the stratified rocks. This saving clause may perhaps suggest the reason why there have been so many conflicting conclusions; the time since the earliest known stratified rocks were formed may be so short compared with the age of the earth itself that the consequences of the very different conditions indicated by astronomers may have left no recognisable trace in those rocks.

SECTION C.—BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE, FORESTRY, PHYSIOLOGY, HYGIENE AND SANITARY SCIENCE.

PRESIDENT OF THE SECTION: Professor H. H. W. PEARSON, M.A., Sc.D., F.L.S.

WEDNESDAY, NOVEMBER 2.

The President delivered the following address:—

A NATIONAL BOTANIC GARDEN.

In these days of specialisation, to address a body of workers representing the various departments of the Science in which one is particularly interested, upon a subject on which one is more or less qualified to speak, is a sufficiently formidable undertaking. To be called upon to engage the interest and attention of the representatives of the range of scientific activity of which this Section takes cognisance—the vast field covered by Bacteriology, Botany, Zoology, Agriculture, Forestry, Physiology, Hygiene and Sanitary Science—is a task which is hardly less than appalling. When, therefore, the Council did me the honour to place me in this position, the choice of a subject in which these few remarks should be centred presented very serious difficulties. To ask you to listen to a discussion in which not more than a small proportion of the members of this section could pretend to be interested did not commend itself; to attempt a review of questions of predominant interest in even a few of the sciences represented here was to commit the offence of dealing with matters of which I know little or nothing. I shall, therefore, make use of this exceptional opportunity of appealing to so broadly constituted a body of workers in biological science, to discuss a topic presenting few technicalities but, nevertheless, one of considerable National importance, and one which I venture to hope will claim the interest of every member of the section.

The subject I have chosen is no new one; it has been before the South African public on many occasions and in many guises. But so far as I am aware it has never before been offered in a more or less definite form for the consideration of a general assembly of those who, by the character of their training and the nature of their occupations, are especially concerned with the scientific and economic development of the country, and it has certainly never been discussed under circumstances in which it is so likely to be favourably regarded as at present. This meeting of the Association witnesses the consummation of the Union of South Africa and, therefore, there could be no more fitting occasion on which to advocate advances or reforms calculated to benefit the country whose interests we have at heart.

I therefore invite you to consider with me the question of the establishment of a National Botanic Garden. It is a subject of such far-reaching importance to a Pastoral and an Agricultural

South Africa that I enter upon it with some trepidation lest any ill-considered words of mine should tend rather to hinder than to forward an object with which I am convinced that this section as a whole will be in full sympathy. The country is so vast, its people so scattered and the interests of different sections of the population in many respects so divergent, that one whose outlook has of necessity been somewhat circumscribed and whose knowledge of the great spaces now united under one Government is somewhat limited, can hardly hope to avoid some of the pitfalls with which this question is beset. But these disabilities may confer at least one advantage; they perhaps prevent me from being overcome at the outset by the magnitude of the difficulties which lie in the way of the achievement of the purpose I am advocating. That this is a real advantage I do not doubt; for the difficulties, great as they may be, will none of them prove insurmountable when we reach them.

The chief danger of which I am conscious at the outset is that, in the attempt to take a broad view of this question, less than justice should be done to the excellent institutions, variously known as "Public," "Municipal" or "Botanic" Gardens, which are scattered up and down the country. They are all alike in that they have done and are doing very useful work which deserves all the support that they receive. In the Cape Province alone there are twenty such gardens receiving in 1909, Government grants varying from £9 15s. to £500, and amounting in all to £1,691. Whatever titles they bear, however, these are not Botanic Gardens in any true sense; the more restricted functions of Municipal Gardens they perform with great credit to their supporters and curators, and no one in advocating the foundation of a truly National Botanic Garden would wish to see their usefulness impaired. On the contrary, they could not but be strengthened by the establishment of such a National institution.

The Natal Botanic Garden stands apart from the rest. It has played no small part in the economic development of the province which it serves and from it has emanated taxonomic work of a high scientific value. On its establishment, more than half a century ago, it received an annual grant of £50 from the Government. This was gradually raised to £350. In addition, the Government contributed, in 1909-10, £260 towards the upkeep of the Herbarium and in aid of the publications proceeding from it. The total income of the establishment in 1909-10 was £2,353 14s. 6d., of which £1,236 19s. 7d. was derived from the sale of plants. It follows, therefore, that the proper work of a Botanic Garden has been very largely subordinated to the necessity of maintaining what MacOwan called "the perpetual fight against insolvency." But, hampered as its activities have been in this respect as well as by its unsuitable locality, unfruitful soil and restricted space (50 acres), it has consistently striven to fulfil the functions of a Botanic Garden. The measure of success which it has achieved is due to the skill and enthusiasm with which it has been guided for more than 28 years by Mr. Medley Wood, its able and respected director.

The oldest of the South African Gardens—the Municipal Gardens of Cape Town—was established under the name of a Botanic Garden in 1848. The objects of the founders, as stated on the subscribers' tickets were:—

1. To introduce from all parts of the globe useful, ornamental and fruit-bearing trees, shrubs, plants, flowers and vegetables, and to promote their distribution and culture throughout Southern Africa.

2. To afford an acclimating resting-place and depôt for exotics in the course of interchange between the eastern and western hemispheres.

3. To afford facilities for the study of Botany as a science and in connection with the horticulture and agriculture of the Cape and for training practical gardeners.

4. To provide, for the recreation and amusement of the public and strangers, a garden with shady walks, arbours, seats, fountains, green-houses and a display of the choicest and most delicate flowers.

These include some of the important functions of a Botanic Garden as this terms is now understood, and the fact that Ludwig Pappe, Karl Zeyher and Peter MacOwan are among those who have controlled its destinies is a sufficient guarantee that a real effort was made to establish here a garden worthy of the name and of the place. And, indeed, the Cape Town Garden has in the past done a great deal in introducing exotic plants into cultivation. But those responsible for its management maintained a long but losing strife against unsuitable locality, poor soil, too limited space, lack of water, inadequate funds and the consequent grinding necessity of making the bulk of the income from the sale of produce. The functions of a Botanic Garden were swamped, and all pretence in this direction was finally abandoned in 1891 when it was taken over by the Municipality. It became, as MacOwan foretold, "but a town pleasaunce of flowers and shady walks," and, indeed it could never have been anything greater. This purpose it fulfils admirably, and it is now, probably more than it ever was before, a credit to the city and to the Corporation as to its curator, Mr. Ridley, whose skill in carrying out many recent improvements is deserving of all praise.

Mention should also be made of two experiment stations recently established in the Transvaal. Skinner's Court in Pretoria, brought into cultivation as a forest nursery in 1902, became a garden for the experimental cultivation of economic plants in 1904. A second station of the same kind, with 25 acres under cultivation, was opened at Springbok Flats in the Waterberg district in 1903. Both these are therefore in their infancy, but so far as can be judged from the available published information concerning them, they will perform some of the important functions of a botanic garden which have hitherto received little attention in South Africa.

The organisation of the Cape Public Gardens has at various times been the subject of comment from men whose opinions in these matters are worthy of our attention. Space does not permit me to notice these so fully as might be desirable, but the general agreement among those who have placed their views on record really renders it unnecessary. It is only fitting that I should commence with our distinguished botanist, Dr.

Bolus, whose great knowledge of South African botany, and intimate acquaintance with the conditions and the needs of South Africa, entitle his opinions to our most respectful attention. In the course of his evidence before a Parliamentary Committee in 1877, Dr. Bolus made statements of which the following is a paraphrase:—

"I consider the Botanic Gardens of Cape Town a great discredit, not only to the town but to the Colony altogether. They are wanting in proper arrangement. There is no satisfactory attention to the nomenclature of the trees and shrubs. There is a great want of a proper representation of Colonial plants, which ought to be the first thing attended to, and there is not a proper communication maintained with the other Botanic Gardens of the world. I think one of the causes of their unsatisfactory state is the totally wrong locality that has been chosen for them. They should be a Botanic Garden of a national character and under the control of Government, and should place themselves in communication with and assist all the other Botanic Gardens in the Colony."

Many conditions have changed since these words were first printed, but the botanic garden which Dr. Bolus wished to see has yet to be established.

A distinguished Indian botanist and forester, Mr. J. S. Gamble, F.R.S., visited the Cape in 1890. His intimate knowledge of the botanical establishments of India invests his remarks with particular interest. He says:—

"As for the Botanic Gardens [of Cape Town], they are simply a disappointment, though the Director, Prof. MacOwan, does his best with the small sums available. The stag-headed appearance of the chief trees points to what is the actual fact, a water-logged subsoil, the bed of an old river, while the untidy and unkempt appearance of the Gardens shows clearly the little interest taken by the Colony in Botanical Science, and points to a want of appreciation of the benefits which a really well-conducted botanical head-quarters station can confer on a country which is, after all, chiefly agricultural. . . . . I was in hopes, when I visited the Garden, of finding a named collection of the Cape heaths, the Proteas, the Geraniums, the Gladioli and the other chief constituents of the beautiful and most interesting 'bush' or 'veldt' vegetation; but the Gardens had not even a single silver-tree to show a stranger, and the heaths, and indeed all flowering plants, were conspicuous by their absence. What ought to be done is to convert the present Botanic Garden into a small park and throw it open to the public, handing it over to the Municipality, who would probably then try to make it as pretty and interesting as such parks are everywhere in Europe as well as in America, India and Australia. And then a new Botanic Garden should be made on suitable soil near some one of the stations on the suburban railway, such as Rosebank or Rondebosch or even Wynberg, and of an area of at least 200 acres so that it might have plenty of space not only to grow and exhibit the indigenous flora but to experiment with exotics. And the absurd idea of such an institution 'paying' should be totally abandoned. If this were done, under the best management, and with a really good herbarium and botanical museum, the Botanic Gardens of Cape Town would be to the Colony what 'Kew' is to England, the Calcutta Gardens to India, or Peradeniya to Ceylon. . . . . A good Botanic Garden would pay indirectly if it did not directly."

Apropos of the transfer of the Cape Town Garden to the Municipality in 1891, the following comments appeared in the Official Bulletin of the Royal Botanic Gardens, Kew:—

"It is to be hoped, however, that botanical enterprise at the Cape has not so entirely died out that it may not be possible at some future time to establish a Botanical Garden, under scientific control worthy of the Colony and of its vast and valuable resources. The Cape Flora is one of the most

interesting in the world. A large number of very interesting and highly-valuable plants belonging to this Flora are gradually becoming extinct. The opportunity for preserving them for observation and investigation will soon pass away. A National Garden, maintained by Government and under suitable scientific control, affords the most satisfactory means for preserving and studying such plants, and this duty is recognised in every important Colony of the Empire. If suitable land, with the necessary climate for a Botanical Garden, could be obtained within easy reach of Cape Town, it is in every way desirable that the idea should not be lost sight of, and that the Government should recognise the duty of providing such a Garden as one of the national institutions of the country.

"Its economic influence, directly and indirectly, upon the development of the vegetable resources of the Colony, may be gathered from the results that have accrued to other Colonies from similar institutions. These, however, are hardly more important than the scientific value attached to the preservation of the singularly interesting plants of South Africa. Such plants could only be successfully cultivated and preserved in an institution where they could be arranged and grown under circumstances entirely removed from the merely local interest engendered by municipal control."

That it may not be supposed that the Cape Town Gardens alone have attracted the attention of those interested in botanical enterprise in South Africa, I will conclude these quotations with two which have broader references. The Director of the Forests and Botanic Gardens of Mauritius, recording his impressions of South Africa, formed in 1883, says:—

"I travelled from Algoa Bay overland to Cape Town. I visited all the Botanic Gardens at the Cape, namely, Port Elizabeth, Graham's Town and Cape Town. They, in many respects, are most disappointing, being Botanic Gardens merely in name. The directors and curators are not to blame for this, but the Gardens have to justify their existence and support themselves by the sale of plants. They are simply nursery establishments, and the stock on hand, generally speaking, is such as one finds in the nurseries at home, stove or tropical plants excepted. They seem to supply a want, the Graham's Town one especially, in supplying the Colonists with flowers, shrubs, and useful fruiting and flowering trees. Should, however, a stranger like myself wish to see African plants he need not look in these Gardens for them."

And finally I will repeat some interesting observations made by the Director of Kew in 1895, with reference to the transfer of the Public Gardens of King William's Town to the Corporation:—

"At the present moment Cape Colony is the only important British Possession which does not possess a fully-equipped Botanical Institution. It is true it possesses a fine Colonial Herbarium under the competent charge of Professor MacOwan and an Agricultural Department which he efficiently advises on botanical subjects. But beyond this it has no central authority dealing with the practical aspects of the Science of Botany, and no gardens under technical control where careful experimental cultivation could be carried on or where special seeds and plants could be obtained for starting new industries. This condition of affairs is scarcely creditable to a large and wealthy community like that at the Cape. The town gardens now established in the more important centres of population in Cape Colony are likely to be useful as breathing spaces and as ornamental adjuncts to public buildings. As purely pleasure gardens, supported by the municipality out of the local rates, they will also have their own special value. It was entirely a misnomer to call them Botanic Gardens and it is as well that the name was changed and their proper character officially recognised.

"Something, however, more than an ornamental garden, dotted here and there, is required in South Africa. A central establishment in the neighbourhood of Cape Town devoted to the scientific study and experimental cultivation of plants, fully equipped to discharge its duties as a national institution on the lines of Kew, would alone be worthy of the future of South Africa.

"The Flora of this part of the world is of extreme interest. It deserves to be carefully and exhaustively studied, and numerous plants, now in danger of becoming extinct, should be preserved in some central spot for the observation of students. On the economic influences of such a central institution it is needless to enlarge. There are hundreds of problems connected with the cultivation of industrial plants in South Africa awaiting solution, and these could only be dealt with at an institution specially devoted to scientific research, where careful trials could be conducted extending over many years."

That these criticisms are almost as true to-day as when they were written, and that South Africa still possesses no scientific establishment with the organisation and the equipment of a botanic garden, are hardly matters for surprise. The subdivision of authority and the divided interests of the South African colonies have prevented that concerted action which was necessary to bring the establishment of a South African botanic garden within the range of practical politics; and the older colonies have not, in recent years, been in a position to find the funds needful to maintain separate institutions which, however great their value to the communities they would serve, could only make an indirect return, and that not immediate, for the expenditure they would occasion. But with the achievement of Union, the more serious obstacles have disappeared, and there is not likely to be a more favourable opportunity than the present for bringing this question once more into prominence.

It will be well to consider what it is that we mean by a botanic garden. An establishment which may justly bear this name performs many functions, and the complexity of its activities would be specially great in a country like South Africa—a country in which the climatic and other factors affecting plant-life are so remarkably diversified; in which the native vegetation is of such exceptional interest; in which so little systematic effort has been expended in the experimental cultivation of native and exotic plants of ascertained or problematic economic value; in which such vast areas are awaiting utilization; in which the pastoral and agricultural pursuits, upon which the real prosperity of the new South Africa depends, offer for solution so many problems of far-reaching economic importance.

The foundation of all botanical investigation, as well as of all those researches into the problems of plant life which fall within the respective provinces of the chemist, the forester and the agriculturist, is a knowledge of the native vegetation. We have in South Africa a group of floral regions which are second to none in scientific interest. With the exception of a few areas, which are very small indeed in comparison with the greatness of the country as a whole, none of these has been thoroughly exploited by the plant-collector and the systematic botanist; and our knowledge of the plants of many extensive tracts is still hardly more than embryonic. From our present point of view the truth of these statements does not rest merely upon the fact that there are yet many South African species undescribed and unnamed. To complete the catalogue of South African species, not only of phanerogams but also of

cryptogams, is an object eminently worthy of our best endeavours and, indeed, not less than a duty which we owe to ourselves and to the rest of the civilised world; but, when all this is done, we have still to learn the geographical range of each species and to obtain a comprehensive knowledge of the life-conditions which control its existence. This knowledge, full of interest as it would be for the student of plant-geography also possesses a great practical value. Recent events have shown once more how great is our readiness to credit wild stories of the discovery of untold mineral wealth, but, on the other hand, we are certainly too prone to believe that many parts of the country are worthless unless they contain marketable minerals. I doubt if such a pessimistic verdict with regard to any large area of the Union Territories is at present founded upon adequate evidence. A very important part of the *data* which alone can justify or controvert such a conclusion is furnished by the native vegetation. For such knowledge of it as we possess we are indebted primarily to the European collectors of the last century and a half, of whose names a South African scientific audience needs no reminder. These men bore the burden and heat of the day in a very real sense, and we who have entered into the fruits of their labours have not given that attention to the completion of their work which the needs of the present, as well as the traditions of the past, clearly demand from us. It is true that botanical exploration has not been allowed to die, but for this we must thank individuals—the few whose names will justly occupy prominent positions in the history of South African Botany, whose work has been ably supported and supplemented by the many who, working in quiet isolation, seeking and receiving no reward, stimulated only by a keen interest in the plants among which they live, will, when everything is as it should be, be deemed worthy of greater honour than some whose names are more widely known. But what has been and still is lacking is the concentrated and organised effort which has its inspiration in a National institution. A South African Botanic Garden, established upon a sound basis would place on the front page of its programme the completion of the botanical exploration of the country. In this work it would seek to co-ordinate individual effort to which we already owe so much, with the official enterprise which till now has been almost non-existent. The scientific importance of this undertaking it would be difficult to overestimate. That practical results would follow can hardly be doubted, but apart from these, an educated community must recognise that it is its duty to know the country in which it lives.

Closely connected with this subject is the cultivation of indigenous plants. It may fairly be said that no other part of the earth's surface offers so great an array of forms of scientific and horticultural importance which lend themselves to inexpensive and effective treatment in a limited space. More than one of the authorities previously quoted have referred to the lack of interest shown in the native flora. People say, no doubt with

much truth, that Cape plants are difficult to grow; but the fact remains that a large number of them, and these by no means the most attractive, have at one time or another been successfully cultivated in Europe; even to-day, when Cape plants are somewhat "out of fashion," you will find at Kew, at Dahlem and I believe also at Edinburgh, Vienna and elsewhere in Europe, a greater variety of South African plants than in the gardens of the Cape itself. Hundreds of visitors touch at Cape ports, especially at Cape Town, during the year. They enquire times without number "Where can we see the Heaths, the Proteas, the Orchids, the succulents, the bulbs and other constituents of the vegetation for which South Africa is famous the world over"? They are told "You must climb Table Mountain, wander over the Cape Flats and visit the Karoo, Namaqualand and the East; we fill our gardens with plants very many of which you can see to better advantage in Europe, the States or Australia; our own vegetation which you are discerning enough to praise is difficult to grow." The inheritors of one of the most remarkable and most beautiful of existing floras, we take so little interest in it that we have not yet been at the trouble to bring its treasures into cultivation! Such as we do find room for, we grow because the enterprise of European horticulturists has made them popular and, as a rule, we are content to be ignorant that we have but brought them back to their own country. This is surely not in harmony with the traditions of South African patriotism! A tardy recognition of a national duty has given rise to legislation designed to protect some of our more attractive and rarer plants from a threatened extinction, but we cannot stop here. The public taste must be stimulated to a proper appreciation of the æsthetic value of one of the most striking of the products of the country, and our duty as custodians of a unique vegetation—many of whose constituents have already disappeared, and others can with difficulty be saved—must be realised. These objects have been forwarded and to a large extent achieved in other countries by National Botanic Gardens, and a similar institution here, with the prestige of a Government Department, administered on scientific lines and accessible to the public would undoubtedly do much to remove what is at present a national reproach as well as a neglect of what might be an important commercial asset. Anyone who has seen Kew on a summer Bank Holiday does not need to be told that an institution of this kind is a valuable means of education. Offering not even the attraction of a band and without any adequate provision for the supply of refreshments, Kew Gardens are thronged with visitors, mainly from London, whose occupations are such as to keep them away at other times of the year.* To realise the extent to which these crowds voluntarily forego the time-honoured privileges of the British picnicker, of strewing the ground with waste-paper and broken glass, and assist the caretakers in pro-

* On the three summer Bank Holidays of 1910 the recorded numbers of visitors to Kew were respectively · 120,561, 152,454, 129,984.

tecting the plants, is to learn something of the lively appreciation felt by the public for such an institution—an institution whose principal attractions are due to a rich collection of plants, admirably grouped, but brought together in the interests of pure and applied Botany and Horticulture. Before leaving the subject of the South African indigenous vegetation, attention should be drawn to the need for its study from an economic standpoint. South Africa, a country of Euphorbias, has done no experimental work designed to remove the difficulties which have prevented them from acquiring a commercial value as rubber plants. Of our native fibre-plants, medicinal, resinous, and poison plants, fodder plants and others, we have very little exact knowledge. Here is a practically untouched field for the activities of a well-organised State Department of Botany.

A collection of plants under cultivation affords opportunities for investigating their structure and life conditions. I need hardly explain that science has not finished with a plant when it has been labelled and placed in a herbarium. In fact, this is only a necessary preliminary to the more intimate study of the living plant. Biologists everywhere are busy with the many ramifications of the problem of life, and we are called upon to do our share in widening the boundaries of human knowledge. Investigations of this character very generally necessitate keeping the plants for longer or shorter intervals under close observation. This demands a garden equipped with experimental facilities and staffed by men trained to make use of them. This department of the work of a Botanic garden is of the greatest scientific importance, and it is therefore incumbent upon a civilised community to foster it, apart from the possibility of any practical results that may emerge. Research is, or should be, undertaken with the single object of discovering truth, regardless of the consequences. These, however, may at any time assume a practical and economic importance which no one has been less inclined to expect than the investigator himself. When the Abbot of Brunn crossed different varieties of peas in his monastery garden he and those who immediately followed him were so little conscious that his work possessed any practical value that it remained unnoticed, indeed forgotten, for more than thirty years. But within the last decade we have seen the rise of a great and influential school of Biologists, who, starting from the basis established by Mendel, have already shewn that, within certain limits, we have the power to produce new races of animals and plants with a precision almost equal to that of the Chemist when he prepares hydrogen by combining zinc with sulphuric acid. The economic consequences thus arising out of Mendel's simple experiments in the early "sixties" are immense, and their limits are not yet to be defined. Work on these lines is in progress in all parts of the world where there are biologists with the means of conducting suitable experiments. In South Africa, so far as I am aware, no serious efforts have been made in this direction, except in the Transvaal and recently at Robertson, under the Departments of Agriculture. But here is a branch of investi-

gation whose influence upon industry is incalculable. An important part of the work of a National Botanic Garden would be the organisation and carrying on of investigations of this character, primarily of course with a view to South African requirements. In so doing, however, it would discharge a wider obligation, for it would bring South Africa into line with the rest of the civilised world.

The introduction and acclimatisation of useful and ornamental exotics was recognised as an important function of a Botanic garden when the Cape Town Gardens were established. A good deal has been done in this direction, but still more remains to be accomplished. The introduction of foreign plants into this country has been of a somewhat haphazard character, and much enthusiasm and expense which might have produced beneficial results, have been largely wasted. Many valuable exotics have come into the country, but no one knows what they are nor where they are, and there is not at present in South Africa a single organisation properly equipped for obtaining and furnishing the needful information concerning them, for submitting them to experiment to determine their local value, nor for maintaining a general oversight and direction of enterprise of this nature. It is hardly necessary to say that there is a risk in introducing a new plant from another region. It may prove itself to be a good servant, but there is always a possibility that, if it is not very carefully looked after, it may become a bad master. South Africa has had many opportunities of learning this. In order to eliminate dangers of this kind, and to ensure that the introduction of new plants is carried out with judgment and economy, and that suitable steps are taken to ascertain and to realise the economic value of the introduced plants under South African conditions, a national scientific institution commanding the confidence of the agricultural community is required.

It has been stated on a former page that the grazing industry presents for solution many problems which would receive attention from the staff of a Botanic Garden. Space does not allow me to deal with these in detail, but I must lay stress upon one of them—a problem of the greatest importance to the future welfare of this great industry, and through it to the whole community. I refer to what is usually known as the "deterioration of the veld." That the feeding value of the vegetation in those parts of South Africa which have been long settled is decreasing is a general belief. It is not difficult to convince oneself that for certain areas at least this belief is well-founded. It is not too much to say that this is a question of the utmost gravity. Slight changes proceeding unheeded for long periods may produce results which would seem to be altogether incommensurate with the magnitude of the changes themselves. While it might be a comparatively simple matter to arrest the downward progress if proper remedial measures were applied in time, a stage is reached sooner or later when Science is powerless. There can be little doubt that many good grazing grounds have been unconsciously allowed to lapse

into desert, and that many more are now moving in the same direction. It is imperative that we should ascertain exactly what is happening in these cases; until we know this we are as helpless as a medical man who is called upon to prescribe for a patient of whose symptoms he is ignorant. All we know at present is that the problem is one of great complexity. Its investigation will almost certainly demand the co-operation of the systematic botanist, the physiologist, the bacteriologist, and the chemist; at least, it is quite certain that it will not be mastered by any one of them alone. It is one of those problems which must engage the combined attention of the staff of a well-equipped Botanic garden, and which is not likely to be solved until the Government is able to command the services of such a staff.

Finally, there must be mentioned a subject which is of great interest both to the Agriculturist and the Grazier—viz., that of plant diseases. A large proportion of these are caused directly or indirectly by parasitic fungi. In a country which grows wheat, mealies, grapes and sugar cane, it is sufficiently well-known that some of these entail economic consequences of the most serious order. As a result of the close attention paid to these matters in Europe and America, our knowledge of plant diseases has advanced in recent years with great rapidity. What has South Africa done to cope with the diseases from which its Agriculturists have suffered so much? The Transvaal alone has realised the importance of this question and has appointed as an officer in the Agricultural Department a highly-qualified expert in Mycology, whose work has justified his appointment many times over. With this exception, no South African Government has made adequate provision for this work. The extended department of mycology which will no doubt result from the centralisation of Agricultural administration, would be most suitably and economically attached to the State Botanic Garden—suitably, because the work of the mycologist at many points touches that of the physiologist, the morphologist and the systematist, and each is benefited by the experience and knowledge of the rest; economically, because if the mycologist has a separate department of his own much of the laboratory, greenhouse, and garden space, as well as the library and equipment, must be duplicated.

I have by no means reached the end of a reasonable catalogue of the activities of a properly organised National Garden, but I have still something to say on another aspect of the question, and cannot spare time to deal further with this one. But I think I have said enough to establish my second proposition—viz., that an abundance of work is awaiting the appearance of such an institution. This work has a strong claim upon a civilised and educated community; much of it is intimately concerned with the prosperity of the country; most of it will remain undone until the Nation, realising its importance, supplies the means for doing it.

I proceed now to the third division of my subject, which perhaps presents rather more difficulty than those which have

preceded it. Nevertheless, the general lines upon which the establishment of a State Garden of the nature indicated above should proceed in South Africa are, I think, fairly clearly indicated. We are dealing with a vast area which, by differences of latitude, altitude and rainfall, is naturally divided into a number of regions differing from one another in the conditions which they impose upon the plants inhabiting them. Each of these has its problems, some peculiar to it, others of more general occurrence; the same problem appearing in more than one region will frequently demand more than one solution. Therefore, quite apart from mere geographical considerations, it is obvious that a single garden, however large and well-equipped, will not serve the whole of South Africa. The economic work which has to be done makes it necessary that each of these regions should possess at least one experimental garden. The compilation of a complete list of these will only be possible when we have gained experience which is not available at present. On quite general grounds, however, it would appear that the following list of experimental gardens includes none that should be dispensed with.

Natal	1
Native Territories of the Cape Province	1
Albany	1
Western Province (Cape)	1
Namaqualand	1
Karoo	1
Orange Free State	1
Bechuanaland or Griqualand West	1
Transvaal	2

The size and equipment of each of these would be determined by the economic requirements of the region in which it is situated. The gardener in charge, not necessarily in all cases a white man, would be trained at the central establishment from which his work would be controlled and directed. The structural equipment in each case would include accommodation for at least one visiting member of the Scientific Staff, as well as for a minimum or more of laboratory work. Five of those mentioned in the list given above would probably be situated where no public garden exists at present; these would practically confine themselves to experimental cultivation mainly of an economic character and, apart from this, horticulture would hardly come within the sphere of their operations. Where, however, the garden lies within an area possessing a sufficiently concentrated white population, its functions would naturally be more extended. In these cases public gardens are already in existence, and might perhaps render the establishment of new ones unnecessary. These institutions are already doing important work under the control of municipalities or of other public bodies and upon this no one would desire to entrench. On the contrary, it would be the natural policy of a National Garden to encourage and assist them in every possible way. They would find it to their advantage to co-operate as far as possible with a central institution and, where desirable, an extension of their activities in

the direction of experimental work would not be difficult to bring about.

One of the gardens suggested in the list must be the centre of administration and of the scientific work. As integral parts of it, there will be: (1) A National Herbarium and Botanical Library; (2) a Museum of Economic Botany; (3) Research Laboratories; (4) Administrative Offices. So much centralisation is absolutely necessary both for administrative and scientific reasons. A good deal of the scientific work will, of course, be done in the field or at one or other of the smaller experimental gardens, but unless the whole system is to be paralysed by incomplete equipment and a diffuseness of purpose which take away all hope of efficiency, there must be for all purposes a common base of operations. As to the Garden itself, it will naturally be larger than any of the others and its functions more comprehensive. In the first place, it will become a school of South African Horticulture—a school in a twofold sense. South Africa has not yet evolved a South African Garden. The National Garden will seek to justify its title; it will gradually discover what can be done with the forms which Nature has so bountifully bestowed upon South Africa, and which have hitherto been so pointedly neglected in the country of their origin. It will teach those who visit it to know their own, and it will become a pleasing object-lesson of the great truth which South Africa has not yet finished learning—that the true springs of her development are within, not oversea. It will also be a school of South African gardening of another kind, for it will train South African gardeners under South African conditions. I anticipate the objection that South Africa has already as many gardeners as it requires. This is hard to believe so long as it is rather the rule than the exception to see a public building or a fine house set in a neglected, unkempt environment

> "Which, like the toad, ugly and venomous,
> Wears yet a precious jewel in his head,"

The term "wilderness," which in the language of the garden connotes something beautiful, must here be often used in other senses—to describe the unchecked tangle of exotic bush or the dusty barrack-yard which so frequently surrounds the human habitation or congregation. That the South-East wind and the cost of labour are to an extent accountable for this state of things is no doubt true. But some lack of interest in these matters, as well as a dearth of working gardeners who know their business are, I think, largely responsible.

And then our central garden will also provide experimental plots for the use of those working in the laboratories; a larger section will be devoted to economic plants, native and foreign, where they will be tried before being distributed to the parts of the country in which they are likely to prove of value. The size of this garden must, in the first instance, be determined by various circumstances; it is not just now a question of importance, as however small the area it could not all be occupied without delay; and however large, it must be capable of exten-

sion. The area suggested by Mr. Gamble—viz., 200 acres—will serve as a basis for discussion.

Which of the localities named is to provide the central garden from which the whole system is to be worked? This is a question of the first importance, and the successful working of the scheme depends in no small degree upon the answer adopted. Among the conditions which the locality to be selected must satisfy, these are of outstanding importance:—

1. Its climate must not be sub-tropical. This follows from the fact that only a small proportion of the country whose interests are to be considered possesses a wet sub-tropical climate. A garden placed in such conditions would be to a large extent out of touch with the subordinate establishments. It is hardly less important to avoid a hot damp climate, in order that the conditions may be as favourable as possible for work.
2. It must be near the sea. This because it is to serve as a centre for acclimatisation. Plants fresh from a sea voyage are not in a condition to withstand a long railway journey over the hot, dry plains of South Central Africa.
3. It should be within an area whose main interests are, directly or indirectly, agricultural.
4. It must possess the conditions of soil and climate which are most favourable to the cultivation of that portion of South African vegetation which is of the greatest interest—scientific, horticultural and general.
5. Lastly, but perhaps most important of all, it must be easily accessible to as large a number as possible of the civilised inhabitants of the country.

The Cape Peninsula is the only part of South Africa which can satisfy all these conditions. Here we have the best climate for continuous work that Southern Africa affords; a place near the sea and yet offering a choice of situations. in which vegetation is not adversely affected by littoral conditions; a locality which has been proved by long experience to be the best suited for the principal Forest Station in the country; a centre which has a larger settled white population and is visited by greater numbers of people from within and from without than any other part of the sub-continent. In the Cape Peninsula there are many possible sites, some of which may be ruled out of court at once. The Cape Town side of the mountain is too crowded, and, moreover, it has already been tried and found wanting. A situation directly facing the sea or in the main track of the South-east wind is to be avoided. Our choice is, therefore, restricted to the Eastern side of the Peninsula Range, and, in view of the fifth of the requirements mentioned above, it is practically limited to the available land between Wynberg and the Devil's Peak—which includes all the localities suggested by Mr. Gamble in 1890. There is no need to be more particular with regard to this matter at present. One cannot, however, pass by in silence the suggestion which has been made more than once, that the Groote Schuur estate possesses many striking

advantages as a Botanic Garden site. It is historic ground and in the eyes of the public is not merely a perpetual memorial of a great man, but it stands for a great ideal whose realisation would be brought nearer by the influences which would emanate from a National Garden. It has been said that the idea of establishing a National University in Groote Schuur is favourably entertained by the Government. If this be so, what could be more appropriate than that these two national institutions, designed to raise the standard of culture and to contribute to the material prosperity of the South African nation, should both be overlooked by the Rhodes Memorial? The direct or indirect association of University and Botanic Garden is nothing new; it has been endured for centuries in many European centres of learning. As an aid to education—not merely the acquisition of botanical knowledge—the botanic garden is an invaluable asset to a University and, on the other hand, the staff of a University Botanical Department can contribute very effectively to the research work carried on in the Botanic Garden.

Even so general a view of this question as I have attempted to put before you must include some reference to its financial aspect. But this is not the occasion, nor do we possess the necessary *data*, for its presentation in any detail. We may, however, learn something of the staff and equipment required from a consideration of a similar system of botanic gardens in another British Colony. For this purpose the island of Ceylon furnishes a useful parallel. I choose Ceylon because I can speak of it with confidence, having studied in its gardens and obtained some knowledge of their administration. Although it is a tropical island, its considerable range of altitude and climatic conditions and the variety of its agricultural pursuits, render it more suitable for comparison with South Africa than would perhaps appear at first sight.

Ceylon has an area of 17,307,000 acres, of which only 3,650,000 are at present under cultivation. Its population in 1907 was given as

Europeans	6,300
Eurasians	23,000
Natives	3,500,000

The first public garden was established in Colombo during the Dutch régime. The parent of those which exist to-day was laid out, also in Colombo, in 1810; it owed its inception to Sir Joseph Banks. Various changes and extensions during the century have resulted in the existing system of botanic gardens, seven in number, distributed as follows:—

1. The central garden, from which all the rest are administered, situated at Peradeniya (1,600ft.), on the outskirts of Kandy, the capital. It is 143 acres in extent. It includes a large area devoted to the ornamental treatment of native and exotic plants, as well as experimental plots. Within it are laboratories, herbarium, library, museums, administrative offices and residences for certain members of the staff.

2. Hakgala (5,600ft.), including about 40 acres in cultivation and 500 acres under indigenous forest and grass. This was opened in 1861 for the experimental cultivation of Cinchona, and has more recently been interested in Tea and other crops suitable for elevated regions in the Tropics.
3. Heneratgoda (15ft.) with 29 acres under cultivation and 10 acres of forest. This station was occupied in 1876 for the experimental cultivation of Para Rubber which, under the auspices of the Botanic Gardens, has now become an established industry. As a result of the work done by the officers of the Department, Para Rubber occupied in 1906 some 115,000 acres in the low country.
4. An experimental station, 150 acres in extent, has recently been opened at Maha-illupalama, in the dry region which extends through the greater part of the northern half of the island and in which there is at present very little cultivation of any kind.
5. An experimental garden of 11 acres is situated at Badulla (2,220ft.), in the midst of an extensive grazing district.
6. At Nuwara Eliya (5,800ft.) a garden of 10 acres was opened in 1902.
7. The Gangaruwa experimental farm, adjoining the Peradeniya Gardens, was opened in 1902. It includes 250 acres under cultivation, worked on commercial lines, and a forest reserve of 300 acres. It has been established for the purpose of growing, on a large scale and under commercial conditions, products which have already been tested in the experimental plots of the Botanic Gardens.

The Director of the Royal Botanic Gardens of Ceylon is, therefore responsible for the administration of 383 acres in cultivation and 510 acres of untouched jungle and grass. In addition, he is chairman of a committee composed of the nominees of the Government and the Planters, and of some members of the scientific staff of the Botanic Gardens, which controls the working of the Gangaruwa experimental farm. The staff of the whole establishment may be classified as follows:—

A.—Europeans with scientific training (seven)—viz.: Director, Assistant-Director, Scientific Assistant, Mycologist, Entomologist, Chemist, Controller of the Gangaruwa Experimental Farm.

These officers are all highly trained scientific men. The Director, Dr. J. C. Willis, F.L.S., was formerly Senior Assistant in Botany in the University of Glasgow.

B.—Europeans with horticultural training (three):—Curators of the Gardens of Peradeniya, Hakgala, and Maha-illupalama.

C.—Herbarium Assistant and Draughtsman (two natives).

D.—Native Clerks (six).

E.—Native Foremen, etc. (twelve).

F.—Native Gardeners, labourers and attendants.

The total cost of the establishment in 1906 was 132,318 rupees. This includes three items which in South Africa are already more or less adequately provided for under the Agricultural Department and neither of which, under South African conditions, would be more appropriately attached directly to a Botanic Garden. These are:—

(1) The Gangaruwa Experimental Farm, costing,		Rupees	30,569
(2) Chemist,	,,	,,	7,000
(3) *Entomologist,	,, (say)	,,	7,000
	Total ..	Rupees	44,569

For purposes of comparison we may take the difference between the total annual expenditure and the cost of these three departments—viz., Rs. 87,749, which, at 15 rupees to the sovereign, amounts to £5,850. This sum is approximately 1-274th of the year's revenue, after deducting the Railway receipts.

The Ceylon Gardens, it should be noted, are the modern development of an institution which has been in existence for more than a century. They have, therefore, long passed the experimental stage. The planters of Ceylon are keen men of business, and although many of them are sufficiently far-seeing to recognise that the value of a scientific institution is not to be judged by the criterion of a mere commercial enterprise, we may be quite sure that, as a body, they are satisfied that this annual expenditure is justified. They could hardly fail to be convinced of this when, to a greater or less extent, they owe Cinchona, Cacao, Coca, Camphor and Rubber, to say nothing of minor crops, to the activities of the Botanical Department which, through its Scientific Staff, has also done a great deal towards the conservation of older established agricultural industries.

In comparing a State Department of Botany such as we should desire to see established in South Africa, with that which exists in Ceylon, certain characteristics in which the two countries differ should be noted. In South Africa the climatic conditions are far less favourable to agriculture. South Africa is the permanent home of a large population which will in time be dependent for its food supplies and, indeed, for its prosperity, upon the products of its soil. The interests of those engaged in agricultural and pastoral pursuits have hitherto received but little assistance from the scientific study of the plants upon which they depend. Little has yet been done in South Africa to render available the products of indigenous or exotic economic plants. A large part of the South African revenue is derived from a diminishing capital. The cost of the lower grades of labour is considerably higher in South Africa than in Ceylon. From a purely economic point of view therefore the need for an organisation whose business it is to undertake the study of applied botany is greater in South Africa than in Ceylon; its establishment and maintenance will also be more costly.

* No details as to cost available.

It appears, therefore, that for South African purposes the £5,850 which Ceylon spends upon the more strictly botanical work of its Botanic Gardens must be increased on account of certain conditions peculiar to South Africa. But this sum represents 1-274th of the revenue. At the time of writing there is no information as to the probable revenue of the Union. In 1908 the total income of the four constituent provinces, with Basutoland, less Railway receipts, amounted to £8,860,876. On the scale which prevailed in Ceylon in 1906 this would have yielded £32,000 for the support of a Botanic Garden.

Such a system of South African gardens as has been suggested above must, of course, be the result of a process of growth; it could not come into existence at once as a finished product. As it advanced beyond the initial stages, and its activities and usefulness extended, the grants that would justly be allocated to its work would naturally increase. Whether the annual expenditure necessary to enable it to render its maximum of service to the State is greater or less than £32,000 can only be determined when we can be guided by experience.

The economic value of a State Department of Botany organised upon a scientific basis and provided with adequate equipment has been abundantly proved in all other important parts of the Empire, tropical, sub-tropical and temperate. What is probably the most efficient Botanic Garden at present existing is maintained by the Dutch in Java; and perhaps the most beautiful by the Republic of Brazil at Rio. The occupation of the Philippines by America has immediately resulted in a great development of botanical enterprise in those islands. The continent of Africa is dotted with Gardens maintained, partly or entirely for economic purposes, by Egypt, Germany, Portugal and Great Britain. The accumulated experience of the nations has found no other satisfactory means of doing the work for which these gardens are established. If South Africa is to proceed upon the soundest and most direct lines in increasing, developing and preserving her agricultural and pastoral resources, she must follow the example set by other nations in the occupation or settlement of new or incompletely known regions.

Important as the commercial aspect of this question undoubtedly is, South Africa cannot ignore another consideration which does not exist in most of the cases referred to above, in which a new country has no immediate prospect of becoming the permanent home of a people of European origin. The South African Botanic Garden cannot be merely an economic undertaking; it must also be an expression of the intellectual and artistic aspirations of the New Nation whose duty it is to foster the study of the country which it occupies, to encourage a proper appreciation of the rare and beautiful with which Nature has so lavishly endowed it.

SECTION D.—ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY.

PRESIDENT OF THE SECTION:—REV. W. FLINT, D.D.

TUESDAY, NOVEMBER 1.

The President delivered the following address:—

This Section covers a somewhat wider range of subjects than is sometimes associated with the name of Science; so wide, indeed, that the inclusion of certain of their number seems to call for special justification. A few of the matters which come within our purview, it must be confessed, do not strictly belong to the realm of pure, or even applied, science, but the fact that they are admitted here may be regarded as evidence that the founders of the Association were of opinion that, varied and practical as the subjects are, they could at least be discussed in a scientific spirit, and that to do so would be in the interests of the community and not foreign to the objects of the Association. That confidence has not been misplaced, as is shown by the work accomplished in the past. The proportion of those engaged in the pursuit of science for its own sake, without regard to the benefits to be secured by its successful prosecution, is probably growing less. The age is utilitarian, and consequently there is an ever-increasing number of those who observe, co-ordinate, and classify the facts and forces of Nature with the special object of utilizing the results at which they arrive for the benefit of the race. Science is thus becoming more and more practical in its aims. The work of this Section has a strong tendency in the direction of utility and practical life, treating, as it does, not so much with nature as with human nature and the means which tend to its advancement in certain relations. This latter fact makes the application of exact scientific method difficult, for we are in almost constant contact with what is variable, flexible, changeful, and that not according to well-defined laws, but subject to the uncertainties and vagaries of what is sometimes perilously near caprice. But that factor, if the foe of scientific exactness, has the possible advantage of being provocative of discussion and widely-extended interest, which results are not altogether to be deplored. However, it is not my purpose either to explain, or defend, the diversity of the subjects included in the Section over which I have the honour to preside, suggestive as is such a line of thought, but to express the hope that the papers and discussions may form together a not unworthy contribution to this year's meeting of the Association.

The time at my disposal I propose to occupy with a particular subject, the importance of which is, I think, in inverse ratio to the amount of public attention which it has received in this country. My paper is entitled:

ARCHIVES AS A NATIONAL ASSET.

If, as has been wisely observed, "the proper study of mankind is man," it should be borne in mind that man has many

relationships, and that not the least important of these is his relationship to the national life of which he constitutes an integral part.

That is a factor which we are not in danger, perhaps, of overlooking at the present juncture in our national affairs, but there are aspects of the individual's relationship to the general development of the State which do not always receive the attention they deserve. The destiny of a nation is largely affected by its genius, and the genius is determined by many elements, of which there is one aspect which specially concerns the subject which I have to discuss. That aspect is the relation of those elements to the past. The material for the effective study of any important phase of national life can never be found in the events or facts of any single generation, and it not infrequently happens that a nation fails to understand itself because it confines its attention too closely to present facts and issues only, or in looking back over the past is unable to see more than a few landmarks of history, to which an exaggerated importance is attached. The long stretches of country which lie between those landmarks are entirely neglected, or, because they are inadequately studied, are regarded as of little value.

That nations misunderstand themselves may sometime be easily accounted for on these grounds. Racial animosities and party strife produce lines of cleavage, and successive generations, yielding to the force of circumstances, are content to perpetuate the partisan spirit because there is no real enquiry as to its justifiableness.

Nor do the historians always provide an antidote; indeed it is not too much to say that in the matter of fairness many a writer of history has much to learn. The personal equation is often allowed to dominate the facts, which are distorted; or truth is made to suffer by neglect or deliberate suppression of motives, words, or deeds. Occasionally history as it is written is affected not only by the personal idiosyncrasies of the historian, but by some temporary disturbance of the local, political atmosphere at the time of writing.

One remedy for such an unsatisfactory condition of affairs is that every country should be provided with adequate, well-arranged, and easily accessible archives, in which shall be deposited records and documents bearing upon the history of the country, and the development of the people in every aspect of the national life.

This necessity is being increasingly provided for in the great European countries, and younger nations, like the United States, are sparing no expense in order to adequately equip the student of history for the task which he sets himself to perform. And so prolific have been its results, indeed so far has this work gone in some directions that in the introduction of that great work, "The Cambridge Modern History," we read: "Great additions have of late been made to our knowledge of the past; the long conspiracy against the revelation of truth has gradually given way; and competing historians all over the civilised world have been zealous to take advantage of the change. The printing of archives has kept pace with the admission of

enquirers; and that total mass of new matter which the last half century has accumulated amounts to thousands of volumes. In view of changes and gains such as these, it has become impossible for the historical writer of the present age to trust without reserve even the most respected secondary authorities. The honest student finds himself continually deserted, retarded, misled by the classics of historical literature, and has to hew his own way through multitudinous transactions, periodicals, and official publications in order to reach the truth."

The aspect of the modern student's position set forth in the concluding sentence may seem to suggest that the advantages of well-equipped archives are not unmixed with difficulties and perils of another kind, but this at least is obvious, that the facts which make for truth are being made available, and though it may not be true that he who runs may read it is evident that he who is prepared to sit down and study national history in many countries has now opportunities to which most of the great historians of the past were entire strangers.

That the colonies should be very far behind the older countries in this matter is not at all surprising, but one fact stands out in the history of the younger nations which is pointedly suggestive here, and it is this—The attainment of nationhood has invariably been followed by a desire to promote the study of the national development. What this has produced in one particular instance has already been referred to in passing, and Washington, with the immense resources at its disposal, has created archives to which it is almost possible to apply such a word as perfect, so thoroughly has the search for material been prosecuted, and so generously and advantageously has it been placed at the disposal of the student.

The Dominion of Canada affords another striking example of the manner in which nationality asserts itself in this direction when once self-government attains its majority in national union. The story of the Canadian archives, though not associated with such large financial resources as that of the United States, and though little more than a quarter of a century has elapsed since the first report of the Archives appeared, tells of most remarkable work attempted and accomplished. Not only has the local material been collected, systematized and indexed, but vast collections of records in Great Britain and France, the two countries most intimately concerned with its history, have been investigated and copied, or in some instances bodily transported to Canada, by permission of the particular authorities concerned.

Following the same national impulse, the Commonwealth of Australia has also made a beginning. The delay in deciding upon a site for the national capital has necessarily delayed the work, but it has not been lost sight of, and the steps already taken to secure records of the early history of the colonies which were united to form the Commonwealth promise to be most fruitful of result as soon as a permanent home for the historical treasures is secured.

How greatly the work of those Archives is valued, and how potent are the influences which they exert, is evidenced

by the increasing number of historical works of first importance which are being produced in the United States and Canada.

It is not too much to say that the world's richest treasures to-day are its ancient archives, those inscriptions on coffins and tablets which are being brought out from Egyptian tombs and unearthed from the mounds under which Babylonian and Assyrian cities have found their age-long resting-places. How valuable even the slightest details of these records prove has been attested by a writer on Egyptian antiquities, who observes on the work of the investigators:—"No object has been deemed too trivial for examination. The relations of one monarch to another have been found on scraps of vases, chips of wood and fragments of papyri. A mutilated heiroglyph on the dress of a statue has revealed a political mystery, and a series of erasures on granite blocks a religious revolution!"

It is not claimed that modern archives can ever in the most distant future assume an importance comparable with that of these few relics from a dim and hoary past, for the means of record have been so greatly multiplied, but that they must always be a great national asset of the people to whom they belong cannot be gainsaid, an asset which can never depreciate but will increase in value as the years increase.

In what particular they become a national asset need not be stated at length, but the more closely nationality is studied the more it becomes apparent that the opinions, the prejudices, the hopes, the ideals, and even the capabilities of a nation are phenomena which can only be adequately accounted for when they are regarded as the resultant of forces which have operated through successive generations in the past. They are not simply the totality of present ideas and influences. They are the results of forces which have worked in a perfectly natural way, and which will continue so to work in the future. It must therefore be of immense advantage to a nation to be able to re-create its past, for it is only in that way that it can come to understand itself and so help on the time when

"the alchemy of years
Has purged the base and left the good
Flawlessly tempered by fine tears,
Welded in perfect brotherhood."

That archives greatly assist in that direction is indicated by the Canadian Archivist in one of his reports—"The effect of the collection of archives has been to modify greatly in many cases the histories of Canada and the United States, and their relations to the mother country."

The very word "Union," which all through the ages has been the stepping-stone from which nations have risen to greatness and true nationhood, presupposes that in the past there has been separation, and separation has usually been a synonym for jealousy and strife, for hatred and war.

Whatever will help a people to clear up its misunderstandings is a possession of real value. But there are other aspects of nationality which claim the attention of a people hoping for a high place among the great nations of the world. National

character, like personal character, frequently has its own weaknesses, idiosyncrasies and defects—a particular class of the community lags behind the corresponding class in other lands. There is usually a cause which can not only be discovered if the resources requisite are made available, but being discovered may be removed. And these are only illustrations of the reasons for that tendency to self-examination which we have seen to be a characteristic of new nationhood.

Now, much of the material for the prosecution of the study of these and other aspects of national character can only be readily found if well-organised archives are instituted. And that study may be accounted a national duty. George Meredith has well said, " I think that a right use of life and the true secret of life is to pave the way for the firmer footing of those who succeed us."

This brings us to the question of what may be regarded as the essential characteristics of well-ordered national archives. If archives are to fulfil such purposes as those which have been briefly hinted at they must be made the storehouse of the materials which constitute the history of the community in its political, ecclesiastical, commercial, industrial, scientific, educational and social relationships.

The time was when the history of a nation was supposed to consist almost, if not altogether, in its monarchial and diplomatic, military and naval records, but it is obvious that in recent years there has been a gradual swing over of interest from such aspects of national life as are connected chiefly with international and governmental relationships to the sociological phases of national life.

The supreme questions are coming to be those which relate to the condition of the people, and to-day's records of these aspects of national life will be of great value in the future. True national archives must then be made comprehensive, and there is no reason why they should be limited to the records of selected phases of national activity. It may not be necessary even to define the boundaries between which the work of the archives should be carried on, for principles are a far safer guide than rules for working purposes.

It often happens indeed that such classes of information as some of these to which reference has been made are found most valuable to those who are engaged upon research in South Africa. Not merely have the official records of outstanding events afforded help, but in the study of the past of this country such despised literature, if literature it may be called, as almanacs and directories, pamphlets and local publications, become of the greatest value. The last becomes first in importance, the ephemeral becomes the permanent.

In attaining its nationhood, South Africa has not to start its archive work at the beginning.

The archives of Cape Colony have already a history, and fortunately the work attempted has never been conceived in a narrow spirit. It is South Africa as a whole which has always been in the minds of those who have laid the foundations of this important enterprise, and South Africa in its widest sense,

including all the territories of this great sub-continent with which what is now the Union has any historical relationships.

There are also, at least, the beginnings of a similar work in the Transvaal, and important documents and records are available in Natal and the Orange Free State, although little systematic work has been done upon them. I need not state at length the history of the archives in this Province, nor do I propose to enter upon the discussion of what may be provocative of controversy as to the manner in which successive Governments have seen fit to deal with the Archive Department. This much, at least, may be stated as a guide to those who desire to pursue the enquiry that as long ago as the year 1896 a Commission was appointed by the Governor of the Colony to collect, examine, classify and index the records. The Commission consisted of men whose names are still well-known: His Honour John Henry de Villiers, Chief Justice of the Colony, the Honourable John X. Merriman, M.L.A., Commissioner of Crown Lands and Public Works, Charles Aken Fairbridge, M.L.A., William Edward Moore, M.L.A., and Abraham de Smidt, Surveyor-General.

The time at which the Commission was appointed so soon after full responsible Government is one more proof that as nations move towards the realisation of their own identity they desire to understand how their development and history manifests itself.

The Report of the Commission's work is in existence as a Parliamentary Blue Book, issued in 1877, and shows that the members of the Commission had a keen appreciation of the value and importance of the duties they were called upon to discharge.

It is tempting to pursue the history of these archives and the archive work which has been accomplished beyond the seas on behalf of the Government of the Cape of Good Hope, but I must be content to mention two names which will ever be associated with the treasures of South African history, the Rev. H. C. V. Leibbrandt, who recently retired from the post of archivist, and Dr. G. M. Theal, whose work is so well-known and so highly-appreciated as to need no commendation from me.

The volumes published by these indefatigable toilers will suffice to give some indication of the historical treasures of which the Union is now the rich possessor as the results of the foresight of the Government of 35 years ago.

Without continuing the historical enquiry it should be here placed upon record that on the retirement of Mr. Leibbrandt, the Government of the Cape Colony, being desirous of placing the work of the Archives on a broad and permanent basis, appointed a Commission, consisting of Mr. C. L. W. Mansergh, I.S.O., afterwards Chairman, Dr. G. M. Theal, Mr. A. C. G. Lloyd, B.A., Dr. Godee Molesbergen, Mr. J. G. van der Horst, and the present writer, whose duties were to submit definite proposals for the future control and management of the Archives, and to suggest the lines on which the public usefulness of the department might be enhanced.

That Commission, it may be stated, has done much important work, and at a very small expense has greatly increased the facilities for research, while it has also been successful in making some important additions to the Archives, and is initiating a plan of search for and copying of important documents which are believed to be in existence in Holland and elsewhere.

Reviewing then, in brief, the history of the Archives at present stored under the Union Houses of Parliament, it may be safely affirmed that since the appointment of the 1876 Commission large quantities of valuable documents have been rescued from oblivion and the hand of the destroyer, have been carefully sorted and bound, and safely housed, and much useful work has been done upon their indexing, while guides to their nature have been placed in the hands of students and of the general public.

It is obvious, however, that these can only be regarded as a beginning, for it has still to be confessed that authors and students of history in South Africa are placed at a great disadvantage, compared with those in many other countries, in the limited nature of the facilities which are at their disposal when desiring to investigate public records, documents, official papers, and other manuscripts which would throw light upon the historical development of the country. Indeed, the Council of the University has frequently hesitated to prescribe for Prize Essays, or the higher Academic honours, subjects which would necessitate research, because it has felt that it would be unfair to ask such work under the present conditions.

What should be aimed at in order to develop the Archives and to enhance their usefulness I may be allowed briefly to outline.

This I would preface by stating that the Union Archives are likely to have much more in common with other colonial Archives in their aims and methods than those of the older countries of Europe. Colonial systems are based upon needs to which our own are closely akin. Perhaps the Canadian Archives are the type which may be followed with the maximum advantage, they having developed from necessities which in many particulars are like ours. Canadian history had relations with two older European countries, the Dominion was an aggregation of colonies whose diversity of interest offers a very close parallel to ours. Moreover, the work accomplished is an index to the value of the system employed.

In South Africa four Colonies have entered the Union, but it is obvious that there cannot be four Archives. Centralisation must be the ruling idea, and remembering the object for which Archives exist, the centralisation should take place as near as possible to the chief seats of learning where research is likely to be carried on. Only thus could they become a true national asset of the highest value. Otherwise, if an attempt is made to establish several Archives, rivalry inconvenience and inefficiency will inevitably result.

There is much material from outside the Government departments and from oversea which remains to be secured, and there

must be no outbidding between rival establishments. That certain records are required for local reference in different parts of the Union does not affect this question, as for purely administrative work the period of years during which reference is required is not very lengthy, and papers are not usually required for the true archives until that time has elapsed.

That opens out the question of how the archives should be constituted as regards the material.

The sources of that material are various. They may be classified as follows:—

(*a*) The source over which the Government for the time being has absolute control. The records and documents of Government Departments and offices find first place in this. Not that all the papers of such offices have an archival value, but the trained archivist will readily discern what is of real interest as bearing on the rights, the history, and the general progress of the nation. For the purposes to be served all such records should be at the disposal of the archivist at the expiration of a term of years to be regulated by the convenience of the Department affected. This, however, should be secured, that such records are not dealt with in a haphazard way, and that the element of personal caprice in the disposal of them shall be eliminated as far as possible. Those who have experience in this direction know that Departments are often very slow to disgorge their documents which, alas! are often so jealously guarded that research among them is almost entirely precluded, and even where allowed the conditions are such that little useful work can be accomplished. Sometimes, on the other hand, the documents are relegated to musty basements and dusty garrets, when that rare combination, the zeal of a fanatic and the instinct of a housemaid, would be required to impel a student to breathe the mildewed odour which infects the atmosphere, or to disturb the dust of the ages. In regard to the large accumulation of documents of this nature in different parts of the Union, a special Commission may be necessary in order to inspect and report upon them, and on the best means of establishing such relations between the Departments and the Archives as will most effectively provide for the sorting and final housing of the documents.

(*b*) Then outside of the ordinary Departments there are records of a more select and exclusive character to which the country has a right in due course. Ministerial documents, Executive Council Minutes, and proceedings of that nature the country is entitled to have at its disposal when the discretionary years have passed during which a closer secrecy is desirable. To these may be added formal legal documents relating to our Constitutional history; correspondence, petitions and counter-petitions, which at different times have expressed the desires and aspirations of sections of the community. The archival value of many of these can scarcely be over-estimated.

(*c*) In the third division of sources of material must be included the treasures obtainable from oversea. The Canadian archives have been greatly enriched by copies of documents, and even in some cases by originals, from England and France,

the two countries closely associated with the early history of the Dominion.

South Africa has its European sources also, for Portugal, Holland and Great Britain have each in turn contributed to the history of this land, and New Zealand has in the Grey collection papers of great value to us, for which happily we have an equivalent to offer which that country is anxious to possess. Already we know something of the records in the European countries which affect us, and such self-denying work as that of Dr. Theal has given us a considerable addition to our asset. He doubtless has knowledge of where our Archives Department might add still more to its stores, and no time should be lost in securing that information if available. State Papers in the Colonial Series of the Record Office in London, War Office records, papers under the care of the Master of Rolls, and various Departments of State can be laid under contribution. The British Museum, the Royal Institution, the old Trade and Plantations Office, now known as the Board of Trade, are in possession of valuable papers, and some of them would probably grant the same special facilities as have been granted to Canada for papers to be copied, and if their actual work cannot all be done at once some competent person might be asked as a preparatory work to make out complete lists of documents to be dealt with as means are provided. It is possible some arrangement might be made to receive help from the Historical Manuscripts Commission, and though this does not exhaust the oversea resources it is sufficient to indicate what a large and attractive field is open for search.

(*d*) To these I would add the more private sources, such as old letters, diaries, descriptive writings, which might be obtained were it known they would be appreciated, and were adequate guarantees forthcoming, which would of course be readily given, that where required they could remain under seal only to be opened at a fixed date when no personal offence could be given. With these might be associated family papers of general interest, while in other cases biographers and other writers have often in their possession, or are acquainted with, large stores of material which they have been unable to use or which they have passed over because it was not germane to the special end which they had in view. Nor should it be forgotten that documents have come into the possession of private families through relatives who have occupied official positions when there was no very sharp line of distinction drawn between what was personal and State property. In some instances the value of these is not understood, not even suspected. One custodian perhaps values them, to the next they are so much waste paper or rubbish, and as such reach the ignominy of a "parade" sale, while diligent historians are sighing their hearts out for the information they contain. Well-considered enquiries might discover some of these, and where necessary to purchase, the fact should not be lost sight of that a £100 within the next ten years may be worth a £1,000 a quarter of a century hence.

(*e*) Then also well-managed archives would doubtless attract large stores of material, which would be invaluable to students of the future who desire to understand the social life of earlier times. There are many religious, philanthropic, educational, scientific, social and even sporting societies, and institutions, which in the nature of things can have no provision for the permanent keeping of their minutes and records for which they have no future use, but which will have an increasing value as bearing on sociology, one of the great studies of the future. Such are the materials which should constitute one of our greatest national assets in the future.

On the treatment which these materials will receive at the hands of a skilled archivist it is not my purpose to dwell. On arrangement and indexing there is much which might be written. On the archivist himself and his staff, their qualifications and spirit, their relations to the student and the public it were an easy task to enlarge, but I forbear. This, however, must be stated, that the staff must be selected with the idea of placing the work upon a sound basis from the beginning, or much waste will be entailed. In arrangement and indexing there must be technical knowledge, and to overcome the drudgery of the task there must be genuine enthusiasm.

In this relation there is one point I would like to emphasize as affecting a wide range of interests outside the archives, and that is the necessity of starting with a fixed arrangement of dealing with the prefixes of our French and Dutch surnames. At present all is confusion, and one is never certain whether research has accomplished its perfect work until it has exhausted all the permutations of "de," and "van," and "der," and the names themselves, a slovenly method and productive of a great waste of time, and, personally, I should like to see adopted what is in vogue in some of the principal institutions of England and the Continent, namely, the principal place given to the name, all prefixes following in a subsidiary position.

Of course this great national asset cannot be realised without money, and even such inteligent assemblies as Parliaments are not always easily convinced of the public utility of work of this nature, while more ignorant persons who call themselves practical, that blessed word which claims so much and often means so little, will perhaps desire to see something more striking for their money, but I hope in some little way, at least we who are interested in this matter may, through this paper and discussion, be able to enlist the sympathy and help of those being wise to conceive and strong to do may assist in developing this idea of South African Archives, which should prove one of the best and mose enduring assets of our Union.

So shall the nation come to know itself, and that knowledge being honestly accepted and candidly considered, mistakes will be acknowledged, weaknesses confessed, and mutual forgiveness extended. That being accomplished, the way will have been opened for a people of one heart and mind, one ambition and hope, to march forward and take its true place among the peoples of the earth.

ASSOCIATION LIBRARY.

The following publications are regularly filed at the office of the Association, South African Museum Buildings, and are available for perusal by members daily between the hours of 9.30 a.m. and 12.30 p.m.:—

General Science.

Memoirs of the Royal Society of South Australia.
Transactions of the Cambridge Philosophical Society.
Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften.
Journal of the Royal Society of Arts.
Servian Royal Academy of Sciences; Comptes rendus.
Atti della Reale Accademia dei Lincei, Rome.
Kungl. Svenska Vetenskapsakademiens Handlingar.
Kungl. Svenska Vetenskapsakademiens Årsbok.
Memoires de la Société de physique et d'histoire naturelle de Genève.
Knowledge.
Annals of the Transvaal Museum.
Sitzungsberichte der Gesellschaft naturforschender Freunde, Berlin.
Annals of the New York Academy of Sciences.
Field Columbian Museum Publications.
Vierteljahrsschrift der naturforschenden Gesellschaft, Zurich.
Atti della Società Italiana per il progresso delle Scienze.
Revista de la Real Academia de Ciencias de Madrid.
Bulletin of the Public Museum of Milwaukee.
Proceedings of the Rhodesia Scientific Association.
Proceedings of the American Academy of Arts and Sciences.
Proceedings of the Royal Society of Victoria.
Report of the British Association for the Advancement of Science.
Bulletin of the Imperial Institute.
Annual Report of the Smithsonian Institution.
Annual Report of the Smithsonian Institution (United States National Museum).
Proceedings of the Academy of Natural Sciences of Philadelphia.
Report of the Australasian Association for the Advancement of Science.
Transactions and Proceedings of the New Zealand Institute.
Transactions of the Royal Society of South Australia.
Proceedings of the Californian Academy of Sciences.
Proceedings of the Cambridge Philosophical Society.
Proceedings of the American Philosophical Society.
Verhandelingen der Koninklyke Akademie van Wetenschappen, Amsterdam.
Koninklyke Akademie van Wetenschappen, Amsterdam; Proceedings of the Section of Sciences.
Archives Néerlandaises des sciences exactes et naturelles.
Records of the Albany Museum.
Annaes scientificos da Academia polytechnica do Porto.

Chemistry, Metallurgy, and Geology.

Journal of the Chemical, Metallurgical, and Mining Society of South Africa.
Royal Society of Science, Stockholm; Arkiv för Kemi, Mineralogi, och Geologi.
Transactions of the Geological Society of South Africa.
Records of the Geological Survey of New South Wales.
Memoirs of the Geological Survey of New South Wales.
Bulletin of the Geological Institution of Upsala.
Abstracts of Proceedings of the Geological Society, London.

Meteorology.

Quarterly Journal of the Royal Meteorological Society.

Agriculture.

Annali della Regia Scuola superiore agricoltura di Portici.
Bulletin of Agricultural Statistics of the International Institute of Agriculture, Rome.

Biology and Physiology.

Royal Society of Science, Stockholm; Arkiv för Botanik.
Royal Society of Science, Stockholm; Arkiv för Zoologi.
Journal of the Linnean Society.
Bulletin of the Wisconsin Natural History Society.
Transvaal Medical Journal.
University of California; Publications in Botany.

Entomology.

Report of the South African Central Locust Bureau.
Zeitschrift für wissenschaftliche Insektenbiologie.

Astronomy.

Transvaal Observatory Circulars.
Observatoire Royal de Belgique; Annuaire astronomique.
Journal of the British Astronomical Association.

Physics.

Die Tätigkeit der physikalisch-technischen Reichsanstalt, Charlottenburg.
Report of the National Physical Laboratory, Middlesex.
National Physical Laboratory; Collected Researches.

Political Economy and Social Science.

United Empire.

Geography and Oceanography.

Società Italiana per il progresso delle Scienze; Bollettino del Comitato talassografico.
The Geographical Journal.

Engineering.

Proceedings of the American Institute of Electrical Engineers.
Journal of the South African Institute of Engineers.

LIST OF PAPERS READ AT THE SECTIONAL MEETINGS.

SECTION A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND IRRIGATION.

TUESDAY, NOVEMBER 1.

1. The Period of the Variable Star S Arae. By A. W. ROBERTS, D.Sc., F.R.A.S., F.R.S.E.
2. Le Verrier's Theory of Jupiter and Saturn. By R. T. A. INNES, F.R.A.S.
3. Notes on Halley's Comet, 1910. By H. E. WOOD, M.Sc., F.R.Met.S.
4. A Plea for the Sewerage of the Cape Peninsula. By T. W. STAINTHORPE, A.M.I.C.E.
5. Determination of the Places of the Planets. By R. T. A. INNES, F.R.A.S.
6. Physical Observations taken during the proximity of Halley's Comet to the Earth. By Prof. W. A. D. RUDGE, M.A.

WEDNESDAY, NOVEMBER 2.

7. Address by Prof. J. C. BEATTIE, D.Sc., F.R.S.E., President of the Section.
8. Two Methods of Farm Irrigation. By C. D. H. BRAINE, A.M.I.C.E.
9. Lighting of Interiors. By Prof. H. BOHLE, M.V.D.E., M.I.E.E.
10. Irrigation Financial Problems in the Breede Valley. By T. E. SCAIFE, M.I.C.E.
11. School Buildings and Sites. By A. H. REID, F.R.I.B.A.
12. The New Union Government Buildings, Pretoria. By W. LUCAS, F.R.G.S., F.R.V.I.A.

THURSDAY, NOVEMBER 3.

13. Some Notes in reference to the Machinery in use in the Transvaal shortly after the retrocession of the country to the British. By H. M. MILLER, A.M.I.C.E.

SECTION B.—CHEMISTRY, GEOLOGY, MINERALOGY, AND GEOGRAPHY.

TUESDAY, NOVEMBER 1.

1. Address by A. W. ROGERS, M.A., Sc.D., F.G.S., President of the Section.
2. The Insizwa Copper-Nickel Deposits. By J. G. ROSE, F.C.S.
3. A New Cape Thermal Chalybeate Spring. By J. G. ROSE, F.C.S.
4. Chemistry and Crops. By A. STEAD, B.Sc., F.C.S.

WEDNESDAY, NOVEMBER 2.

5. Karroo Soil, Lucerne, and the Ostrich Feather. By Prof. P. D. HAHN, M.A., Ph.D., and the late D. S. STEVENSON.
6. A Geyser in South Africa. By Prof. P. D. HAHN, M.A., Ph.D.
7. Some Notes on the Treatment of Sands for Stope Filling. By T. DONALDSON.
8. Some Notes on Resultant Gases from certain Explosives. By W. CULLEN.
9. A rare Copper Mineral. By Prof. P. D. HAHN, M.A., Ph.D.
10. Fertilisers from the Ocean. By M. LUNDIE and R. W. HALLACK.

THURSDAY, NOVEMBER 3.

14. Notes on the Geological Formation of parts of German South West Africa. By W. VERSFELD, B.A., B.Sc.
15. Nots on the occurrence of Gold in the Prince Albert Division. By W. VERSFELD, B.A., B.Sc.
16. Acetylene as a Heating Agent in Chemical Laboratories. By Prof. B. de St. J. VAN DER RIET, M.A., Ph.D.

17. Notes on the Constitution of certain Rocks of the Archaean Age in the Province of Natal. By J. A. H. Armstrong, F.C.S., F.G.S.
18. The Development of Gold Extraction Methods on the Witwatersrand. By H. A. White.

Section C.—Bacteriology, Botany, Zoology, Agriculture, Forestry, Physiology, Hygiene, and Sanitary Science.

TUESDAY, NOVEMBER 1.

1. Occurrence of a Spek-boom in the Transvaal. By J. Burtt-Davy, F.L.S.
2. *Crotalaria burkeana* and other Leguminosae Poisonous to Stock. By J. Burtt-Davy, F.L.S.
3. Morphology of the Maize Inflorescence. By J. Burtt-Davy, F.L.S.

WEDNESDAY, NOVEMBER 2.

4. Address by Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S., President of the Section.
5. Hygiene as Applied to School Life. By A. H. Reid, F.R.I.B.A.
6. The Cape Klipfishes. By Prof. J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S., and W. W. Thompson, F.Z.S.
7. Leaf Protection in *Oldenburgia arbuscula* DC. By Rev. F. C. Kolbe, B.A., D.D.

THURSDAY, NOVEMBER 3.

8. Atmospheric Variation as a factor in Evolution. By Dr. D. Traill, M.A. B.Sc.
9. A Brief Outline of the facts concerning the composition of the Snake Fauna of South Africa, and its relationship to the Madagascar Fauna. By J. Hewitt, B.A.

Section D.—Anthropology, Ethnology, Education, History, Mental Science, Philology, Political Economy, Sociology, and Statistics.

TUESDAY, NOVEMBER 1.

1. Address by Rev. W. Flint, D.D., President of the Section.
2. The Sacrifice of Reconciliation amongst the Ba-Ronga. By Rev. H. A. Junod.
3. Hittites in Central Africa. By J. K. Erskine.
4. Bushman Rock Pictures at D'sjate. By Dr. H. A. Spencer.
5. The Growth of an University. By Julia F. Solly.
6. A Logical Notation for Mathematics. By R. T. A. Innes, F.R.A.S.
7. Ancient Copper Mine near D'sjate. By Dr. H. A. Spencer.

WEDNESDAY, NOVEMBER 2.

8. The Transferable Vote in Municipal Elections. By Dr. J. Brown.
9. The Influence of the Darwinian Theory on Ethics, with special reference to the ethical conditions of the struggle for existence. By Rev. R. Balmforth.
10. The Borderland of School and College. By C. D. Hope, M.A.

THURSDAY, NOVEMBER 3.

11. The Treatment of Juvenile Offenders. By J. M. P. Muirhead, F.S.S., F.R.S.E.
12. The Latest Reform in the University of Paris. By Prof. R. D. Nauta.
13. Random Thoughts by a Schoolmaster. By A. S. Langley.
14. Another View of Education in Primary Schools. By G. F. Ayers.
15. Bushman Paintings in Basutoland. By Miss Wilman.
16. On the alternate vote and the only effective method of applying it. By Dr. J. Brown.
17. Dante's Treatise on Government. By Rev. S. R. Welch, D.D., Ph.D.

A PLEA FOR THE SEWERAGE OF THE CAPE PENINSULA.

By Thomas William Stainthorpe, A.M.I.C.E.

A few weeks ago, when I had the honour to receive an invitation to contribute a paper to this Section, I felt some difficulty in selecting a subject. The Society, in terms of its title, exists primarily for the *Advancement* of Science, and so a paper to be read at this Congress might reasonably be expected to record some definite *Advance*—some small addition to the foreshore of knowledge reclaimed from the ocean of the unknown. But the lines of my life-work have, for the most part, been cast otherwise, and chiefly in the direction of the practical application of ascertained knowledge and experience to the needs of everyday life. On reflection, however, I felt certain that the scope and interests of the Society might safely be taken to cover the domain I have referred to, and I therefore decided on venturing to take up a little of your time on this occasion with a matter which affects the daily life and health—and I may add the pockets—of a considerable section of the local public, viz., the sanitary removal service and sewerage system of the Cape Peninsula.

In the first place I may state that the urban portion of the Peninsula is governed by no less than ten Municipalities, viz.: Sea Point, Cape Town, Woodstock, Maitland, Mowbray, Rondebosch, Claremont, Wynberg, Kalk Bay, and Simonstown. The remaining, or rural portion of the Peninsula, is now under the jurisdiction of the newly-constituted Rural Council for the Cape Division.

The present population of the Municipalities is approximately estimated as follows:—Sea Point, 9,656; Cape Town, 66,500; Woodstock, 29,000; Mowbray, 8,500; Claremont, 14,972; Maitland, 6,500; Rondebosch, 6,000; Wynberg, 19,000; Kalk Bay, 2,800; Simonstown, 4,627.

The present population of the rural area embraced within the Cape Peninsula is stated to be approximately 29,000.

It will thus be seen that the present Municipal population of the Peninsula is 167,555, including the coloured.

Why it takes the united wisdom of ten public bodies with ten separate staffs with their separate Town Halls, Town Clerks, Town Engineers and rating authorities for such a small population, has always been a source of wonder and mystery to me, and does not speak well for the wisdom of the long-suffering ratepayers.

I refer to this point at the outset because I am confident that had the Peninsula been governed by one strong unified authority, Board of Works or Council, the present backward and deplorable insanitary condition of a large portion of its area would long ago have been attended to and improved. I am also convinced that large sums of money have been needlessly spent and frittered away, which might have been saved, for want of sound practical advice and experience, by some of these Lilliputian Municipalities. At the same time I must give my meed of praise to those Municipalities who have

already at considerable cost carried out a system of main sewerage for their respective areas.

In the first place I shall briefly deal with the latter Municipalities, viz.: Cape Town, Green and Sea Point, Wynberg, Kalk Bay and Muizenberg, and also Simonstown.

Cape Town, with a population of 66,500, can now boast of an efficient and well-designed system of main sewerage, which has cost the city £258,875. The main outfall is near the Lighthouse at Green Point, where the sewage is discharged into the sea. This constant flow of so large a volume of crude sewage, without any attempt, even roughly, to screen it before discharge into the sea—the foreshore of which is covered with dwellings in very close proximity—may have been deemed satisfactory at the time of its construction, but I think that time has arrived when the matter should be re-considered by the authority responsible. As time rolls on, this discharge of crude sewage will increase, and enlightened public opinion will demand a less objectionable method of disposal.

The marine suburb of Green Point and Sea Point has also carried out on the whole a very satisfactory system of sewerage, at a cost of about £50,000. Exception must, however, be taken to the main intercepting sewer in Beach Road, which is evidently laid with a very flat gradient, necessitating frequent cleansing. No doubt this state of affairs could be largely remedied by the construction of automatic flushing chambers at suitable points. The outfall sewer discharges crude sewage into the sea a short distance to the east of the Hall Road Railway Station, and it is generally admitted that a great improvement would be effected if the point of discharge were carried further out to sea.

Going southward from Cape Town, Wynberg is the nearest Municipality that has provided a system of sewerage for the *Wynberg portion* of its area. The main outfall is laid along Ottery Road, and gravitates to the sewage disposal works, where it is treated on the bacterial system, and the effluent is used for irrigation on a small farm near Princess Vlei. The cost of this scheme, including the recent relaying of the 24″ C.I. pipe outfall sewer and sundry necessary alterations at the sewage disposal works, has been about £118,000.

The Plumstead portion of the municipality is still unsewered, the pail system being in use, but the existing disposal works and farm are capable of dealing with the sewage from this portion whenever the system is extended over the whole area of the municipality. Wynberg, with its plentiful supply of water and storage capacity, and its system of sewerage, occupies the enviable position of being self-contained within its municipal area, and is therefore so far independent of all the other unsewered municipalities in the Peninsula.

Kalk Bay and Muizenberg Municipality next claims attention as being in possession of a recently-completed sewerage system. The cost has been very heavy, and necessitates two pumping stations. Altogether, the sum of £95,201 has been spent on this scheme, including an installation of electric lighting. I do not wish to criticise this enormous expenditure

—compared with the population and valuation—beyond stating that this Municipality has not, in my opinion, got good value for its money.

Simonstown Municipality completes the list of municipalities which, at considerable expense, have had the courage to provide a water carriage system of sewerage. There are several sectional outfalls discharging directly into the sea.

The remaining municipalities in the Peninsula, viz., Woodstock, Mowbray, Rondebosch, Claremont and Maitland, have still this sewerage problem to face and grapple with, and it is for these areas that I plead most earnestly that public opinion should be aroused and educated up to the point of demanding that the present insanitary, extravagant, and disgraceful state of affairs should be swept away, and a more enlightened policy and a cleaner and healthier method of disposal of its sewage be adopted as speedily as possible. I feel strongly upon this subject, and as a sanitarian of over 25 years' practical experience I have no hesitation in saying that I consider the existing state of affairs, in this twentieth century, to be nothing short of a scandal and disgrace to the community. Whilst vast sums of money have been expended by these municipalities in the erection of town halls, street-making and other works, the real root and foundation of the public health, viz.: the efficient and cleanly disposal of sewerage, has been most shamefully neglected, and at this present moment, in many cases, the channels in the streets may be seen flowing with liquid filth.

The following statement is prepared from information kindly supplied to me by the Clerks of the said Municipalities, to whom my thanks are due for their trouble in so doing, viz:—

Name of Municipality.	Population.	Area in Acres.	Assessable Valuation.	Number of Dwellings.
Woodstock ..	29,000	1,609	£2,998,379	5,200
Mowbray ..	8,500	1,600	£1,417,415	1,876
Rondebosch ..	6,000	2,079	£1,004,500	1,123
Claremont ..	14,972	3,790	£1,731,792	2,498
Maitland ..	6,500	4,160	£480,777	1,200
	64,972	13,438	£7,632,863	11,897

Name of Municipality.	Stercus Disposal.			
	Number of Pail Closets.	Frequency of Removal.	Total Annual Cost.	Average Cost per head.
Woodstock ..	5,600	Weekly	£6,500	4·48 shillings
Mowbray ..	1,976	,,	£1,635	3·85 ,,
Rondebosch ..	856	,,	£1,194	3·98 ,,
Claremont ..	2,000	,,	£2,066	2·77 ,,
Maitland ..	1,000	,,	£250	0·77 ,,
	11,432		£11,645	

Name of Municipality.	Slopwater Disposal.		Water Supply.	
	Total Annual Cost.	Cost per head per annum.	Sources.	Daily Consumption.
Woodstock ..	..	..	Suburban W.W.	Not given.
Mowbray ..	£900	2·12 shillings	,,	
Rondebosch ..	£782	2·60 ,,	,,	
Claremont ..	£1,854	2·48 ,,	,,	
Maitland ..	..	..	,,	

Name of Municipality.	Water Supply. Cost per 1,000 gallons.	Assessable Value per head.	Remarks.
Woodstock ..	..	£103·39	Cost of Slopwater not given.
Mowbray ..	..	£166·75	
Rondebosch ..	1s. 4½d.	£167·41	Exclusive of O'Brien closets.
Claremont ..	1s. 0d.	£115·67	
Maitland ..	..	£73·96	Slopwater is not collected ; the cost of Stercus removal is difficult to understand.

From this it will be seen that the total extent of these unsewered municipal areas is 13,438 acres, or roughly 21 square miles, and embraces a population of about 65,000.

It will also be noted that the annual cost of the pail removals, which is done only once a week, amounts to no less a sum than £11,645. In addition to this large expenditure, Mowbray spends £900, Rondebosch £782 and Claremont £1,854 annually on the removal of its slop water, whilst the expenditure of Woodstock and Maitland for this branch of its sanitary work is not stated. And in this connection it may be remarked that in all the areas mentioned only a proportion, and in most cases only a small proportion, of the bedroom and kitchen slop water is removed, the remainder, with waste water from baths, domestic washing and so forth, being run on to gardens, yards, open spaces or into street gutters. Filthy liquid still runs down many of the open street channels, and the river Liesbeek, which should be a beautiful crystal stream—whose banks are thickly populated on both sides—is nothing more or less than a foul and intolerable open sewer during the hot and dry summer months, and a menace to the public health. Surely all reasonably-minded people will agree with me when I say that such an existing state of affairs, in one of the most beautiful portions of sunny South Africa, leaves much to be desired and calls loudly for a drastic change.

Notwithstanding all that has been said and written upon this important subject during the past 20 years, the fact remains that a very large and thickly-populated portion of the Peninsula is to-day in the same state as it was in 1891, when Mr. Clement Dunscombe, a well-known Sanitary Engineer, who

prepared a scheme dealing with the sewerage of the Cape Peninsula, stated in his accompanying report:—

"I have condemned as strongly as possible the collecting system as it obtains in the Cape Peninsula; it is, in my opinion, the most insanitary and most offensive system that could well be devised, and even if performed with moderate regularity its annual cost far exceeds that of a complete system of sewerage and sewage disposal."

He further adds:—

"It is hoped that the example shown by Cape Town will be followed by the Suburbs and that the sanitary condition as a whole will be improved."

At this juncture it may be interesting to state that the scheme prepared by Mr. Dunscombe included the following Municipalities, viz.:—

Municipality.	Population in 1891.	Prospective Population.
Wynberg..	6,047	12,000
Claremont	6,237	13,000
Rondebosch	3,378	6,000
Mowbray..	3,108	6,000
Woodstock	4,973	10,000
Green and Sea Point ..	2,900	6,000
Totals ..	26,643	53,000

The estimated cost of Mr. Dunscombe's complete scheme of sewerage, as shown upon his plan, was as follows, viz.:—

Municipality.	Population.	Estimated Cost.
Wynberg..	12,000	£35,200
Claremont	13,000	46,200
Rondebosch	6,000	34,100
Mowbray..	6,000	24,200
Woodstock	10,000	20,900
Green and Sea Point ..	6,000	23,100
Totals ..	53,000	£183,700

This works out at £3 12s. 8d. per head of the prospective population provided for in the scheme. As before stated, only two of the above Municipalities, viz.: Wynberg and Green and Sea Point, have carried out schemes of main sewerage since 1891. It is not my intention to criticise the scheme prepared by Mr. Dunscombe, except to say that I consider the proposal to dispose of the sewage by means of broad irrigation upon the several areas shown upon his plan would have been highly unsatisfactory and unworkable, owing to the impermeable nature of the subsoil, especially that of the large area upon the Maitland Commonage, which consists of dense, ferruginous conglomerate several feet thick, with only a thin covering of sand.

It will be noted that Mr. Dunscombe provided for double the existing population of 1891. Upon the same basis the united populations of Woodstock, Mowbray, Rondebosch, Claremont and Maitland would be twice 65,000, or 130,000. Allowing the same estimated cost per head, viz.: £3 12s. 8d., the total estimated cost would amount to £472,333. This estimate may or may not be sufficient for a practical and well-considered scheme, but I am certainly not going to express a definite opinion upon this point, as it would only be mere guesswork to do so. Furthermore, I would add that no engineer who values his professional reputation could give any reliable or close estimate until such a careful and detailed scheme was prepared which would necessarily involve a careful contoured survey, and the preparation of all necessary plans, sections, working drawings and specifications, etc. Assuming that this amount were sufficient, the annual cost for interest and redemption for a 40-years loan would be only £23,615 per annum, or 3s. 7½d. per head for the estimated population provided for. In addition to this there would of course be the annual cost of maintenance and working expenses to provide for, but this would not be a very serious item in a well-designed scheme.

It will, of course, be argued that a water-carriage system of swerage cannot be constructed until a sufficient supply is guaranteed for the municipalities in question. This is a *sine quo non* for the success of any sewerage scheme, and any attempt to provide or construct such a scheme without adequate supply of water would be to court certain failure and serious danger to the public health. The supply of water for domestic purposes should not be calculated at less than (an average for white and coloured) 30 gals. per head per day, which would mean a volume of 1,950,000 gals. per day for the present population, gradually increasing to 3,900,000 for the estimated future population which the scheme should provide for. I am not in a position to state definitely whether the above volumes are at present available from the combined supplies of the Peninsula, or whether it would be necessary first to increase the existing supply, but it is obviously the bounden duty of the unsewered Municipalities to ascertain their exact position in this matter, and, if necessary, to take early and practical action to ensure a sufficient supply.

From recent reports of the Council meetings of these unsewered Municipalities, I have noticed that there is an effort being made seriously to discuss this sewerage question, but it has struck me as being very strange that the Municipality of Maitland has never been invited to the suggested conferences. Is Maitland to be ignored from a joint scheme and left to the solution of its own sewage problems? If so, I think a serious blunder will be committed, seeing that its position on the foreshore of Table Bay entitles it to have an important voice in the question of the disposal of the sewage of the Cape Peninsula. This naturally brings one to the question of the best means of sewering the areas to be dealt with and the best place and

method of the disposal of the sewage. To this question there can be, in my opinion, only one possible answer, and the plan I have prepared will, I submit, best and most briefly supply it. To begin with, my scheme would be to construct: (1) A main intercepting sewer along the lowest lines of the Liesbeek River Valley; (2) a main intercepting sewer along the Black River Valley; (3) a main intercepting sewer from Woodstock; (4) a short intercepting sewer from Maitland, all to gravitate to and form a junction at the most suitable point obtainable in the vicinity of Montagu Bridge, where it will be necessary to construct a pumping station to lift the sewage through a rising main to disposal works, to be constructed on a suitable site on or near Paarden Island. The method of treatment I would recommend would be the Bacterial, as follows:—The sewage would first pass through a screening chamber, thence into and through a series of sufficiently large Anaerobic tanks of an united capacity sufficient to hold rather less than a day's volume of sewage, thence by a continuous flow over a sufficient area of aerobic filter beds, the effluent from which would be collected and conveyed by means of a stoneware and C.I. pipe of sufficient diameter to a point well below the low water ordinary spring tide of Table Bay. This system of disposal would produce an excellent effluent, and its discharge into Table Bay would not create the slightest nuisance or smell whatever. One of its great advantages would be that the whole of the Sewage Disposal Works could be enclosed within a very small area of land. Any proposal to discharge crude sewage into Table Bay would be no doubt strongly objected to, and rightly, by the Table Bay Harbour Authority. Some people might advocate the pumping of the crude sewage on a prepared area for irrigation purposes on the Cape Flats. This idea is of course worthy of consideration, but I believe the most satisfactory and economical method of its disposal will be found in the bacterial system I have briefly indicated.

With regard to the branch or street sewers, these should all be laid with glazed stoneware spigot and socket pipes of standard thickness and suitable diameters, with straight lines and even gradients from manhole to manhole. Ventilation should be secured by tall cast-iron shafts placed in suitable positions, and special attention should be made for the automatic flushing of all branch sewers.

The house drainage should be properly disconnected from the street sewers, and every soil pipe should be not less than 4″ in diameter and carried up well above the roof for ventilation.

Time and space prevent my dealing more fully with this important and interesting problem, but if I have in the slightest degree succeeded in drawing public attention to and creating an interest in this subject, which has an important bearing upon the comfort, cleanliness and health of many thousands of residents in the Cape Peninsula, I shall feel amply rewarded for any little trouble I have taken.

In conclusion I would remark that this sewerage question is closely bound up with another and very important one, viz.: The unification of the Municipalities in the Cape Peninsula. One strong administrative body would be in a much better position to deal with the problem than are the existing small Municipalities. The importance of the matter was recognised by the appointment of a Government Commission as far back as 1902, which, after exhaustive investigation, strongly recommended a scheme of unification. Nothing has, however, resulted, and it seems to me that, in the general and public health interests of the community, the time has arrived for a definite re-opening and re-consideration of this question.

SOUTH AFRICAN ALCYONARIA.—Dr. J. Stuart Thomson, F.L.S., has communicated to the Royal Society of Edinburgh the first of a series of papers which he intends to issue on the subject of South African Alcyonaria. The collections were made under the auspices of the Cape Government during a term of several years, and the author acknowledges a grant of £20 from the South African Association for the Advancement of Science towards his expenses. In his paper, Dr. Thomson confines himself to the consideration of the Alcyonacea, the work on which was carried on in the Zoological Institute and Museum of Natural History at Berne. Thirteen species are described, of which the following had previously been undescribed:—*Bellonella studeri*, from St. Francis Bay, near Port Elizabeth; *Metalcyonium natalensis*, from the Umhloti River mouth, Natal; *Alcyonium fauri*, from the vicinity of Cape St. Blaize, Mossel Bay; *Alcyonium rotiferum*, from Keiskamma Point, *Capnella gilchristi*, from the neighbourhood of Cape Morgan, and *Malacacanthus rufus*, found near Seal Island in False Bay. The paper was accompanied by a large number of photographs and sketches.

HYGIENE AS APPLIED TO SCHOOL LIFE.

By Arthur Henry Reid, F.R.I.B.A., F.R.San.I.

It is my wish and object, in submitting this paper, rather to reach the lay than the professional class of our members, because I feel that the importance of the subject is not appreciated sufficiently by those who are members of our School Boards or by the parents of our children. It has for some years been a disappointment to me, in my contact with the local government of South Africa and in my connection with public societies formed for the improvement of our common health, to feel that an undercurrent of suspicion or doubt exists in the minds of very many as to the necessity of introducing the subjects of Hygiene and Physiology, even in an elementary form, into the curriculum of the teacher's training and of the school course generally. For some years there has been, I feel, a tendency on the part of public men and the laity to belittle the advice of scientists and professional men and women: an inclination to discount their opinions as to the outcome of extreme zeal, and to "pigeon hole" their recommendations because in them they foresee more work for themselves and expenditure for the ratepayers. In this spirit, and through ignorance of the subject, I feel that matters affecting the public health and interest have been thoughtlessly postponed, to the detriment of the scientific knowledge and public intelligence.

With the above postulate I propose to advance the case as affecting the school life of our South African children in a simple, popular manner, hoping that our members will at least think over the facts adduced, and do their best to convert specious critics, who may for one reason or another be disposed to favour a destructive rather than a constructive policy in public affairs.

Another object that I have in view is to introduce a liberal and practical view of modern school life into the deliberations of those who have the management of our educational system in their hands, and also, if possible, to induce the electors to place only experienced, educated members upon their School Boards. Until this step is effected, the ethics of education and the scientific conduct of its affairs cannot be hoped for.

To proceed with my subject, I would ask any persons who are in doubt as to my contentions, to visit any public school with an open and unprejudiced mind to see for themselves. They will at once see the varying phases of physical and mental ineptitude in the scholars. They will notice the vigorous intelligent worker imbibing and assimilating all he or she hears without effort, and the weakly, inept mind upon whom the labour and encouragement of teacher and fellow scholar is wasted. The one will necessarily outstrip the other before the real struggle of life commences. Naturally, the visitors wonder why such a difference exists, and if they know anything about such cases, visit the home of the unfortunate child. There they will probably find a mother who has no

conception of the merest rudiments of personal or domestic hygiene: one who is not aware that her child is half starved through improper feeding, or cannot realise that he is suffering from some physical weakness that is stultifying his mental faculties. The next point that suggests itself is: why does not the mother know these things? Why was she not instructed in them by her mother, by her school teacher, or somebody who was responsible for the rational and natural training of her childhood to prepare her for the duties and responsibilities of life? Or, maybe, they find the horrors of a home cursed by indolent or dissolute parents, or perhaps the sad spectacle of *bona fide*, honourable poverty, or of sickness presents itself. Which of these or other causes it may be, the result is the same, and the difference in the two children is accounted for.

Now, putting aside all excuses, let us honestly look around for a remedy. We are loth but compelled to admit that little can be done at the home to secure immediate relief for the child of parents who know no better, but we must and do realise that much can be done at school by sympathetic and conscientious teachers, especially if they are conversant with even the rudiments of physiology and of human weakness. By insisting upon the observance of the rules of hygiene, simple though they may be, the child will be taught to think and to acquire habits of personal discipline that are necessary to his physical, moral and mental development.

Here, in Africa, under our new Union Government, we are to-day at last brought face to face with the subject of school hygiene, a subject that has, for local reasons, been neglected in the past. According to statements made at the late Cape Division School Board in May last, there are about 1,100 boys and girls of European descent, in the Cape Peninsula alone, between the ages of 6 and 13, running wild and aimlessly about, without even rudimentary education. Under the blessings of our new government and the adoption of compulsory education this is now a thing of the past. Now, those who have travelled and seen the effects of advanced education upon the economical and political interests of modern nations, insist that national education must be something more than a mere rudimentary or primary course, and that even the elements of any educational system must be so arranged as to form a curriculum anticipating the study of science to some extent, or in some form, as being a condition precedent to the success of the humblest scholar.

Now, in making this statement, I do not wish to be misunderstood. I am not advocating an advanced scientific education for every boy and girl, but simply what I have written, and, if substantiation is necessary, I would ask why, in so many industries, especially in those depending upon chemical science, our German cousins have outdistanced us in the past quarter of a century, to the serious displacement of our work-people. Their success, I submit, is not altogether attributable to advanced scientific knowledge and research, or to the lamentable attitude assumed by the leaders of labour organisations in England, but rather to the natural intelligence and industry

of the masses, which is the result of their system of popular education. By it the worker is taught that the result of the researches of the scientist naturally aids the achievements of the technologist in his attempt to apply science to industrial operations. The pure scientist, by research, discusses the fundamental laws and principles of science, while the applied scientist aims at assimilating those laws and principles to the processes of reproduction, and to the operations of daily life. Those operations require specially-trained operatives, and they require that " spirit " of science that cannot be attained unless they possess the physical, mental and moral attributes of, at all events, a sound rudimentary technical education, which cannot be attained *unless* (here is my point) *the hygienic condition of home and school are favourable to their bodily and mental development.*

Now, in South Africa, it must be admitted that, as far as general public education is concerned, we are upon virgin soil, but with the advantage of having only ignorance to deal with, instead of the prejudices, superstitions, and vices of the over-crowded and demoralised communities to be found in Europe. At the same time it is unfortunately a fact that, for the same reason, we are not possessed of teachers who have had the advantages possessed by their *confrères* in the older countries of studying personal, domestic and school hygiene.

It will therefore be necessary to teach them the subject before they can impart such knowledge to their scholars. With that hypothesis in view, my remarks may now be directed more especially to the teaching profession and the members of public School Boards in the South African Union.

As the duly-appointed delegate of the Cape and Transvaal Governments to the Congress on School Hygiene held in London in 1907, I had an excellent opportunity for observing, from behind the scenes, the many difficulties that underlie this matter; but I found it quite impossible to rid myself of the conviction that the nature of those difficulties only proved the more conclusively the necessity for overcoming them. Through the courtesy of Sir Lauder Brunton and the Congress officials, I had the advantage of attending the meetings of special Committees where the difficulties were under discussion, and I am pleased to feel that few of them require attention in this country at present, as our social and political atmosphere is less tainted by political intrigue and prejudices than is that of the older countries. The whole question is most carefully dealt with in the report of the Committee of the British Association for the Advancement of Science upon " The condition of health essential to the carrying on of the work of instruction in Schools."*

From this report it will be seen that the subject of school Hygiene not only offers excellent opportunities for practical work and testing methods, which increase its interest to

* Report Brit. Assn. for Adv. of Sc., 1904. Section L (Educational Science).

learners, but it is co-ordinated with nearly every branch of the teachers' work, and affords a living ground-work to all educational methods which *must* be based upon conditions of health that are favourable to school work. The laws of health, if taught in schools, would have little effect upon the scholar unless they were observed and vigorously practised in the every-day routine of school. Such work, it was admitted, could only be accomplished by teachers who had been themselves trained, by practical and experimental work, to understand how and why the laws of health enter into every branch of school life, mental, moral, and physical, and that the facts must be inculcated into the child by observation, sympathetic correction, and experiment.

The Committee, in suggesting a curriculum for the training of teachers in school Hygiene, set forth a *minimum* standard of knowledge which covered the *elements* of general science, including biology and physiology as they affect school life. They felt that the theoretical study of hygiene rarely stimulated practical application or brought home real conviction of its truths, and, therefore, the teachers' course should cover a personal acquaintance with experiments, appliances and methods of proofs and instruction. Much stress was laid upon the two chief obstacles to the success of a large proportion of scholars, viz., exhaustion or starvation in one form or another. The first hardly applies to this country, where compulsory education is enforced and child labour prohibited by law: I wish the second could be as easily dismissed, especially in the white schools. I was particularly struck, both at this Congress and at that of the Royal Sanitary Institute at Glasgow, with the magnificent work done by lady doctors and lady inspectors of schools—work that could not have been done by male inspectors.

The matters dealt with by these ladies are so immense, however, that I must give a small account of their discoveries and recommendations, which should appeal to the sympathy of any intelligent and benevolent person.

One lady delegate insisted that the training of *head* teachers, at all events, should include some clinical experience, because an untrained eye would not detect ailments, and thus children would be classed as mentally deficient who were really only suffering from defective hearing or eyesight. It was further advanced that lady managers could, when required, bring teachers and parents into touch better than men could. Another pointed out how unsuitable the school time-tables were. Mental arithmetic immediately after the midday meal was a mistake; lessons were too long, and, therefore, the power of attention and assimilation was soon exhausted. It was insisted that brain-taxing work should be interspersed with moderate physical exercise, and that it was unreasonable and cruel to expect a half-starved or inept scholar to do the same amount of work as a stronger or more capable child. Again, it was advanced that more attention and work could be secured from children in cool than in hot weather, and

that without proper and scientific lighting and ventilation of school-rooms it was practically a waste of time to attempt to teach them. Now, if such psychological facts obtain in Europe, how much more serious are they in a hotter climate such as ours.

I am of opinion that the present system of long vacations reacts detrimentally upon children, and that it would be better to have more vacations of shorter duration, or, as an alternative, to have instructive amusements provided for the children, especially of the humbler class, at intervals during the long vacations. The study of Nature, the visiting of museums, gardens, factories or ships, under sympathetic escort, classes for drawing, music, physical culture and manual instruction suggest themselves as desirable interludes to idleness in evil surroundings, which would provide their minds with something to talk about. The monotony of child-life can only be relieved and its natural intelligence cultivated by a change of scene, company and occupation.

No doubt some teachers will condemn my proposals because they would entail the sacrifice of their leisure, but I am assuming that our first duty is to serve the children, and the second so to re-arrange the teachers' hours and duties as to render their work as easy and pleasant as possible.

Now, I cannot, at this juncture, pass a subject that I believe every parent feels very strongly about, and that is the exhausting tax inflicted upon themselves and their children by the ever-increasing home-work. There is, I submit, something radically wrong when a father or mother, after an exhausting day, has to give up an hour every evening to teach the children lessons that they think they have paid a master to teach them. They believe that while they are doing this, the teacher is enjoying his or her leisure, and that the process is destructive to their child's health and mind. I am quite sure that not one child in a hundred between the ages of 12 and 16 has finished home-work before 9 to 10 o'clock of an evening, and that, as a rule, our children, considering climatic conditions, etc., are much over-worked, and as a result their digestive and nervous systems become exhausted, and they are the more susceptible to attacks of diseases well known to all capable teachers and intelligent members of School Boards.

It would be unwise for me to enlarge upon the medical side of personal hygiene, but I feel it a duty to call the attention of those interested to some of the commonest and most serious weaknesses that any teacher should be capable of detecting.

The Eye.—In this country of sunshine, children are more free from ocular defects than in centres where artificial light has to be resorted to in day time, but the teacher should be on the watch for shortsightedness, longsightedness, squint, or colour-blindness, and at once report the matter for medical advice, due attention being given to the fact that children with defective vision cannot be expected to do the same amount of work as those not so affected. In any case, the school pro-

gramme should be so arranged that the periods of eye work would, in affected children, be shortened and greater time for rest and change left between them. "Extra work," such as music, drawing and needlework and home study, should be curtailed in such cases.

The Ear.—The practice of boxing a child's ears often leads to a rupture of the drum-head that may injure him for life. Children should be warned against introducing pen-holders, pencils or other things into their ears. Deafness in a greater or less degree should be looked for among children, as ear troubles often follow colds, enlarged tonsils and adenoidal growths, while hardened wax is often a cause of trouble —adenoidal growths are very serious if not detected and dealt with under medical supervision.

The Mouth and Voice.—Adenoids or enlarged tonsils also affect a child's speech, facial expression and breathing.

The principal vocal defects are stammering, stuttering, lisping, drawling and hurried, thick or indistinct speech. A nervous temperament generally intensifies vocal weakness, and, as much depends in after life upon a good vocal faculty, any weakness should be reported and dealt with under medical advice without delay. Congenital defects, such as hair lip, cleft palate or defects in the lips, teeth, tongue or palate naturally require looking for.

Contagious Diseases.—It may not be out of place, as I am more particularly addressing our lay members, to point out that "contagious" diseases are usually transmitted by direct contact, and "infectious" diseases through the media of water, food or air. To give some idea of the necessity for regular and continuous medical inspection, I venture to name a few of the common diseases that may be communicated by one child to another, and thus a whole school be thrown into confusion, either or both of which events might possibly have been prevented if the teacher had been competent to detect them in time.

Usually *air borne* are chicken-pox, erysipelas, influenza, measles, mumps, scarlet fever, small-pox, whooping cough, etc.

Usually *air or water borne* are diarrhœa, dysentery, diphtheria, enteric fever, etc.

Usually *air borne or by inoculation* are tuberculosis, scrofula, lupus, opthalmia, tetanus, ringworm, etc.

There can be no doubt that no greater good can be done in school work than by the study and application of hygiene to *prevent* the diseases that ravage our children. It is unjust to the clean child from a clean home to be forced into contact with one that is neglected and knows little of personal cleanliness.

Preventive Measures.—Children should be taught the dangers of drinking from a cup that has been used by a score of others. Teachers should know how to prevent such a dangerous practice, and members of School Boards should realise the necessity of providing proper sanitary drinking

fountains. The danger of over-crowding coats, hats, etc., needs little comment, I hope.

The regular publication and distribution among school teachers of statistics and advice taken from the reports of medical inspectors would be a most useful guide to them, and would probably be the means of saving thousands of children from misery and loss of valuable time, not to mention impaired mental faculties thereafter.

I have already pointed out the absolute necessity of regular and continuous personal medical inspection of all schools and scholars and teachers as a preventive measure.

General Health and Over-work.—From personal observation I am of opinion that our girls are generally over-worked, and that insufficient allowance is made for the climate and domestic conditions of this country. I feel that in too many cases their future happiness and success in life is jeopardised by too much being forced upon them before they have reached the age of seventeen. Can it be denied that many of the nervous ailments that trouble women could be traced to over-work in unwholesome rooms in a trying climate. I do not wish to go into details, but feel very strongly that it is not sufficiently realised that the life led by a girl between the ages of 10 and 14 is full of import for weal or woe in her future life, which is too often sacrificed to the shrine of ignorance, indifference, or neglect on the part of the mother, teacher, or School Board inspector. The results of such treatment may be seen in many a school-room and many a home every day, in children who are on the road to physical ruin and misery through anæmia, indigestion (or in other words starvation), neuralgia, insomnia and other nervous developments. The cruel stupidity of keeping a dull child in after school hours, on account of inefficiency, should be considered a reflection upon the training, intelligence and humanity of a teacher, for surely such treatment will make him the more dull and discomposed, if not evil-natured.

Diet.—A subject that needs the closest attention of a teacher and mother is that of the nutrition and diet of children. A teacher under medical advice should be competent to detect such a case, and to instruct both child and mother as to the quality and quantity of foods that are most suitable for delicate children during school life, a time when both physical and mental development are most exacting, and when each is more or less governed by the other.

Rest and Sleep.—Children should be taught to rise sufficiently early in the morning to have ample time to clean themselves and eat their breakfast slowly. They should be taught the habit of eating deliberately, decently and naturally. This cannot be expected unless the child is peacefully asleep at a reasonable hour, with brain composed and in those hygienic surroundings that are a condition precedent to physical and mental repose.

Exercise.—Mental relaxation is a most necessary concomitant to successful teaching, and nothing conduces to it more than

moderate and common-sense physical exercise and unrestrained play. Calisthenics should be a compulsory subject in every school curriculum; but here again the teacher's knowledge of hygiene and physiology is necessary to determine the amount and description of exercise that weak or delicate children should take, and to differentiate between sexes and the ages of each class. Calisthenics should be given early in the day's work, and should not be over-done, as physical fatigue is no more conducive to mental work than is mental weariness to bodily activity.

Respiratory gymnastics are most useful and necessary to the poorer children who have spent a night in over-crowded and ill-ventilated rooms. The habit of breathing through the nose, instead of through the mouth, is a valuable precaution against certain diseases and pulmonary complaints. May I again refer to medical inspection as being necessary for the furtherance of this simple but important factor of school life, if only to guard against the error of violent exercise being taken immediately after a meal. Older and stronger children will, of course, indulge in the more violent exercises of the field and playground, but care should be taken that the less hardy cease when the point of bodily fatigue is reached. Every teacher should show interest in outdoor sports and exercise, for there can be no doubt that far too many children are encouraged to spend their spare time with books, that they may excel in their studies, rather than to fortify themselves for the struggle of after-life by cultivating their bodily and mental vigour and individuality through the medium of sport and social emulation.

Punishment and Encouragement.—In view of the old system of corporal punishment having almost disappeared, there is not much to be said about it except to congratulate modern teachers upon the excellent results of their disciplinary measures, which are founded upon the assumption that the first duty of a teacher is to study the character of the children under his or her care, and then, by judicious treatment, to restrain rather than to repel them. Obstinacy in evil-doing or insubordination when persisted in certainly needs severe treatment and punishment, not in anger and not without previous caution and persuasion. Constant reprimands for trivial faults, which are natural to children, rather tend to render them fruitless, and no good teacher would run the risk of exciting a child's spite by harsh language, or his anger by exaggerating his misdeeds, or of attacking his self respect by contemptuous treatment.

Praise or encouragement, when it is deserved, generally has good results, but it must not be fulsome, or such as tends to make a child vain or conceited. Rewards are naturally appreciated, but care must be taken that they do not appear as bribes or as a condition precedent to the child doing his duty. Girls should on no account be physically punished, pulling or boxing of the ears, slaps or blows upon the head are both dangerous and aggravating, and keeping in during recess is

an irrational punishment that results in mental and physical exhaustion. The task of standing for long periods tends to injure the spine, and the abominable imposition of writing long extracts or committing matter to memory spoils both the handwriting and nature of a child.

I submit that the most satisfactory means of correcting, as a rule, is by depriving the culprit of privileges or pleasures that are accorded to the better-behaved scholars. A knowledge of physiology or hygiene would debar a teacher from inflicting any task that would be greater than the child's ability, and would suggest to him that the failure was perhaps rather due to bodily defects or affliction than to vice or carelessness.

Accidents or Illness.—A teacher should know enough of "first aid" to deal with any of the many casualties that occur in the school-room or play-ground until medical aid arrives, and such articles as bandages, absorbent cotton, smelling salts, etc., should be regularly kept at hand.

In conclusion, I would again remark that my paper is confined to the personal side of school life rather than to the buildings and surroundings within which that life is spent, and the trouble of preparing it will be more than compensated for if the eyes of those who have not had opportunities of studying this very important subject are opened to its many possibilities.

MIGRATION OF LOCUST BIRDS.—In order to obtain definite evidence in regard to the flights of the White Stork and other migratory birds, European ornithologists have adopted the practice of affixing an inscription around one of the legs. In the annual report of the South African Central Locust Bureau, recently issued, a record is given of seven storks thus marked in Hungary and one in Germany, and afterwards reported from South Africa. One of these was found at Glencoe and one at Polela, in the Province of Natal; two were found in the Transvaal, at Ermelo and Wolmaransstad respectively; one was discovered at Morija, Basutoland, one at Cradock, Cape Province, and two in the Orange Free State, viz., at Senekal and at Boshof.

TRANSACTIONS OF SOCIETIES.

Chemical, Metallurgical, and Mining Society of South Africa.—Saturday, August 27th: J. Moir, M.A., D.Sc., F.C.S., President, in the chair.—"The efficiency of labour underground": T. **Johnson.** Remarks on the payment and organisation of mine labourers.—"Ventilation and health conditions on the mines of the Witwatersrand": S. **Penlerick.** A discussion of the means to be adopted in dealing with and obviating the causes of disease amongst the Witwatersrand miners, due to dust, the spread of tuberculosis, and the effects of the fumes arising from the employment of explosives. The ventilating system installed at the East Rand Proprietary Mines was described.

Saturday, September 17th: Prof. G. H. Stanley, A.R.S.M., M.I.M.E., Vice-President, in the chair.—"The distribution of pulp for Tube Milling": G. A. **Robertson.** An illustrated description of an improved method for distributing pulp equally between 10 to 15 tube mills.—"Notes on battery

practice": A. R. **Stacpoole.** A description of various stamp mill accessories illustrative of common battery practice on the Witwatersrand mines.

Saturday, October 15th: J. Moir, M.A., D.Sc., F.C.S., President, in the chair.—"New method of lighting fuse": E. M. **Weston.** A demonstration of a convenient method of igniting fuses without the risk of inhaling poisonous fumes.

GEOLOGICAL SOCIETY OF SOUTH AFRICA.—Monday, September 19th: Prof. R. B. Young, B.Sc., F.R.S.E., F.G.S., President, in the chair.—"The Kheis series": Dr. A. W. **Rogers.** A discussion of the mutual relation of the Marydale beds, Wilgenhout Drift beds and Kaaien quartzites and mica schists and of the correlation of the Kheis series.—"The replacement of quartz by carbon in Rand Banket": Prof. R. B. **Young.** The relation of carbon to quartz in the matrix of the banket rock is such as to suggest partial replacement of the quartz by carbon. Microscopic examination of the quartz pebbles showed numerous carbon bodies embedded in the quartz, these bodies possessing a botryoidal form and penetrating to the very centre of the pebble.

SOUTH AFRICAN SOCIETY OF CIVIL ENGINEERS.—Wednesday, October 12th: H. H. Elliott, A.M.I.C.E., President, in the chair.—"Practical notes on Tunnelling": Prof. A. E. **Snape.** A description of the method of construction, engineering details, surmounting of difficulties, and supervision of two large contracts, amounting in value to nearly £750,000 and consisting mainly of two outfall sewers built, for the greater part, in tunnels.

ROYAL SOCIETY OF SOUTH AFRICA.—Wednesday, October 19th: S. S. Hough, M.A., F.R.S, President, in the chair.—"An investigation into the land and sea breeze conditions at Port Elizabeth": A. G. **Howard.** A second contribution on the part of the author to South African meteorology.—"Graphical representation of some of the simpler analytic functions of a complex variable": E. T. **Littlewood.** The paper was illustrated by means of models. Algebraic, exponential and logarithmic functions were illustrated by a wire frame work through which on the horizontal bases families of curves illustrating the various arguments were visible. From these certain general results were established.

CAPE CHEMICAL SOCIETY.—Friday, December 2nd: Prof. P. D. Hahn, M.A., Ph.D., President, in the chair.—"Note on the Analysis of some Californian wines": Prof. P. D. **Hahn.** The results were given of analyses of a number of Californian wines which had recently been analysed by the author after having been kept by him for over ten years. In two cases appreciable quantities of salicylic acid were found.—"Malt vinegar and Maize vinegar": Dr. C. F. **Juritz.** A record of analyses of about six dozen samples of malt and other vinegars, including several recently imported, and a discussion of the possibility of applying analytical limits in the case of vinegars manufactured from whole maize grain and from maize grits or rice.

ADDRESSES WANTED

The Assistant General Secretary (P.O. Box 1497, Cape Town) would be glad to receive the correct addresses of the following members, whose last known addresses are given below:—

Bell, W. Reid, M.I.C.E., F.R.Met.Soc., M.I.E.S., P.O. Box 2263, Johannesburg.
Boulton, H. C., c/o Messrs. Pauling & Co., Ltd., Broken Hill, Rhodesia.
Champion, Ivor Edward, P.O. Roberts Heights, Pretoria.
Dickie, Andrew, 475, Currie Road, Durban, Natal.
Mirrlees, W. J., 9, London Chambers, Durban.
Nichol, Thomas Thompson, P.O. Box 34, Springs, Transvaal.
Nicholas, W. H., Durban High School, Durban, Natal.
Pakes, Dr. A. E. H., P.O. Box 5, Belfast, Transvaal.
Preston, James, 89, Arnold Road, Observatory, near Cape Town.
outhwell, Miss Jessie, 270, Visagie St., Pretoria.

ABSTRACT OF PHYSICAL OBSERVATIONS TAKEN DURING THE PROXIMITY OF HALLEY'S COMET TO THE EARTH.

By Prof. William Arthur Douglas Rudge, M.A.

The advent of Halley's Comet this year was an event looked for with great interest all over the world, and in order to record any unusual phenomena, it was decided to take observations at Grey University College, Bloemfontein, of the following:—

(1) Variation of the potential gradient in the atmosphere.
(2) Variation of the magnetic elements.
(3) Conductivity of the air.
(4) Spectroscopic examination of the light from the sky.
(5) Presence of dust in the air.
(6) Collection and spectroscopic examination of samples of air.

(1), (2) and (3) were carried on daily for a period of three weeks; one week before, and one week after the week when the comet was nearest the earth.

(4), (5) and (6) were carried on during the 17th, 18th and 19th of May.

(1) *Potential Gradient.*—This was measured by a special form of electroscope fixed 1·2 metre above a level piece of ground. The collector consisted of an aluminium wire furnished with a small plate coated with a radium salt. This collector proved very efficient, and has been in use for other atmospheric observations for more than four months without any loss of efficiency. Up to the 17th May observations were taken as frequently as possible during the day, from about 7 a.m. to 11 p.m., and were continued all through the 18th and 19th. From this time until the 26th they were taken as time permitted.

The general result was that a maximum potential gradient occurred at about 8 a.m. and another smaller one at about 6.30 p.m. The times are not very definite, as presence of cloud and direction of wind, etc., had some influence, but during the period of observation the times of maxima did not vary much.

Table 1 shows the observations for the 18th and early morning of the 19th of May. The potential gradient is of course proportional to the deflection. Only a few observations are here recorded, but at some parts of the day they were taken at intervals of one or two minutes, over 400 in all.

Table I.

Time. May 18th.	Deflection.	Time. May 18th.	Deflection.
7.0	29	11.15	30
7.30	40	12.15	20
8.0	60	1.0	4
8.30	62	2.20	15
9.0	57	3.30	15
9.45	53	4.30	20
10.30	35	5.15	25

TABLE I.—*Continued.*

Time. May 18th.	Deflection.	Time. May 19th.	Deflection.
6.0	30	1.0	22
7.0	45	2.0	15
8.0	40	3.0	15
9.0	40	4.0	15
10·0	36	5.0	17
11.0	20	6.0	25
12.0	20		

On the 14th the maxima occurred at 7.45 a.m. and 7.30 p.m. on the 31st at 9.15 a.m. and 7.15 p.m.

No very unusual disturbance occurred between 7 a.m. on the 19th. During that time the comet changed its position relatively to that of the earth and the sun, and if any passage of the earth through the tail really occurred, it must have taken place during the interval.

(2) *Conductivity of the Air.*—A set of observations was taken on the rate of leak of a charged electroscope. An electroscope was fixed to the top of a metal chamber, and through the latter a current of air could be drawn by a water pump, or the air, after filling the chamber, could remain at rest. From the electroscope a brass rod connected to the gold-leaf system passed down into the chamber. The latter was earthed so that any abnormal conductivity of the enclosed air would increase the rate of leak from the electroscope. The electroscope was charged and the rate of leak determined by a reading microscope with a micrometer in the eye-piece. The deflection of the gold leaf being initially 50 scale divisions, it was found that the rate of leak was about one division in five minutes when the air was at rest, and practically the same when the air was being drawn through in a continuous stream. The rate of each was fairly constant during the three weeks, but on the morning of the 18th there was a distinct change, as the following table shows:—

TABLE II.

Rate of leak of charged electroscope. Morning of 18th May, 1910.

Air at rest.		Air in motion.	
Time.	Deflection.	Time.	Deflection.
0	42·0	0	49
5	40·5	5	46·5
10	39·0	10	43·0
15	37·5	15	41·0
20	36·5	20	38·5
25	35·5	25	37·5
30	34·5	30	36·0
35	33·5	35	34
40	32·0	40	32·5
45	31	45	29·0
50	30	50	27·0
55	29	55	25·0
60	25	60	24

Observations were taken every five minutes, as the instrument was usually charged with negative electricity. The rate of leak on the morning of the 18th was nearly twice as great as that on other days, and this irregularity was not again observed and not to anything like the same extent. As far as I know at present the comet's tail could not have been near the earth at this time, and so the increased rate of leak must have been due to some other cause.

It may be asked: "What electrical disturbances might have been expected?" To this question no very precise answer can be given, but it was not unreasonable to suppose that if the tail consisted of fine particles driven by some repulsive force from the sun, such as the radiation pressure, these particles would have been electrified, and on entering the atmosphere, or even if they approached near to the earth, would have exerted some influence on the electrostatic field surrounding the earth; or if they actually entered the atmosphere would have had some influence on its conductivity. From the observations it seems clear that no such effect was produced at the time of the passing of the comet.

(3) *Magnetic Observations.*—It was at first intended to take observations of declinations and dip, and from there to deduce the total force, but owing to the non-arrival of apparatus, the declination only could be taken. The apparatus used was a Kew pattern Magnetometer tested at the National Physical Laboratory. This was set up in an underground room in which the temperature was very constant. Observations were taken for three weeks, and, with one slight exception, showed no unusual variation. There was an increase in the declination at 10.30 on the night of the 18th.

Table III. gives the value of the declination in terms of the position occupied by the cross wire on the scale of the instrument, as the variation only, and not absolute value was required. The maxima occurred at about 10 a.m. and 10 p.m., but on the night of the 18th the maximum was at 11.10. The change was, however, of a very small order, and not more than would have been caused by a slight megnetic storm. The maxima occurred at about the usual time on the morning of the 19th. The magnetic observations recorded in the following table represent the period from 10 p.m. on 18th to 12.30 p.m. on 19th May.

The value of 1 scale division of the instrument is 58″.

TABLE III.

Normal day.		Normal day.	
Time.	Position of cross wire on scale.	Time.	Position of cross wire on scale.
8.15 a.m.	19·9	5.30	19·7
9.30	19·95	6.20	19·7
10.30	20·3	7.5	19·9
11.30	20·1	8.30	19·9
12.30 p.m.	19·95	9.30	19·95
2.0	19·7	10.30	20·00
2.40	19·7	11.30	19·9
4.0	19·65	12.0	19·85

TABE III.—*Continued.*

May 18th & 19th.			May 18th and 19th.		
Time.		Position of cross wire on scale.	Time.		Position of cross wire on scale.
10.0 p.m. 18th		19·88	2.0 a.m. 19th		20·25
10.45	..	20·1	3.0	..	20·08
11.0	..	20·3	4.0	..	20·03
11.10	..	20·4	5.30	..	19·9
11.30	..	20·4	8.30	..	19·8
12.0	..	20·38	10.30	..	20·1
12.30 a.m. 19th		20·3	11.45	..	19·9
1.0	..	20·3	12.30	..	19·8

(4) *Spectroscopic Examination of the Light from the Sky.*—All that could be done in this direction consisted in directing a wave length spectroscope towards the sky, near to the sun, and observing whether any lines appeared to become more intense, special attention being directed to the neighbourhood of the Coronium line. Nothing definite could be recorded.

(5) *Presence of Dust in the Air.*—In order to collect any fine particles which might have been brought into the atmosphere by the comet, an experiment was made by drawing air for twenty-four hours through a series of twelve glass bulbs containing distilled water, all with several plugs of well-washed cotton wool in order to catch any dust. The water left in the bulbs was carefully evaporated in a platinum dish and the vessel tested for radioactivity. Only a very slight trace was obtained. There was a small deposit of a very fine red substance seen upon the cotton wool in the first bulb, but it was ultra-microscopic and probably consisted of the usual atmospheric dust.

(6) *Spectroscopic Examination of the Air.*—Samples of air were taken in an exhausted tube furnished with stopcock and electrodes. The tube was rapidly exhausted by a Fleuss pump to about 1 mm. and the spectrum examined when a discharge was passed through the tube. A chart had been prepared on which the principal spectrum lines had been marked and the lines observed in the spectrum were plotted upon this.

Observations were taken on the 17th, 18th and 19th from 4 p.m. on the 18th to 5 a.m. on the 19th, at intervals of an hour. The spectra in all cases were coincident. A quantity of about 1·5 litre of air was collected in an exhausted bulb; the nitrogen, oxygen, etc., being removed by sparking over caustic potash. The residue showed the spectrum of Argon, the red lines being very distinct. A line in the yellow, due to Neon, could also be recognised, but no trace of Helium.

A similar experiment was made with gas collected on July 3rd, and this yielded an identical spectrum. We may conclude that no new gas was introduced by the comet into the atmosphere.

All the experiments have thus yielded negative results, and if the comet's tail actually did envelope the earth it certainly did not produce any marked chemical or physical change in the atmosphere. A sharp look-out was kept for meteors, but

only the average number was seen. At 2.30 on the morning of the 19th the tail extended for a considerable distance above the horizon, nearly up to the Milky Way, and on two occasions I saw a faint sharp line pass like a flash of lightning at right angles to the tail just near the extremity. The length of the flash was about as wide as the tail, viz., 2° or 3°.

The light from the tail was always strongly polarised.

I have to express my thanks to Professor Rindl and to the students of the College for their very efficient assistance in the arduous task of taking many hundreds of observations. Although the results are negative they are of interest as showing that the presence of a comet's tail has no influence on terrestial phenomena. The question as to whether we actually passed through the comet's tail is, as far as I am aware, not definitely proved.

Perhaps Mr. Innes' theory that the earth would exert a radiation pressure and drive it away is correct. It is to be hoped that astronomical observations will be published which will clearly indicate the actual relations of the earth and the tail of the comet at about the 18th of May.

HIGHER EDUCATION OF NATIVES.—Mr. K. A. Hobart Houghton, in the December issue of *United Empire*, appeals for practical aid in connection with the establishment of a College for the Higher Education of Natives, which it is proposed to build at Fort Hare, near Lovedale, on a farm of about 700 acres which has been secured for the purpose. The control of the College will be in the hands of the Governing Council, whereon will be represented the Government, the Founders (European and Native), the University, and the Churches co-operating in the movement. In connection with the College hostels will be built by the Anglican, the Wesleyan, and the Presbyterian churches. A sum of £50,000 in all is required, whereof £40,000 has already been promised, £18,000 of this having been subscribed by natives. This sum has been placed in the hands of a Board of Trustees, the Rev. Principal Henderson being chairman, with the following colleagues: Hon. J. W. Sauer, Senator Col. W. E. Stanford, C.M.G., Col. the Hon. C. P. Crewe, C.B., Senator the Hon. W. P. Schreiner, K.C., Rev. Prof. J. I. Marais, D.D., Dr. N. MacVicar, and Messrs. J. G. Weir, N. C. Thompson, J. Tengo Jabavu, S. P. Gasa, and K. A. Hobart Houghton.

SOME NOTES ON RESULTANT GASES FROM CERTAIN EXPLOSIVES.

By William Cullen.

Since my last communication on this subject* a great deal of work has been done, mainly by myself and assistants, and public interest has been aroused, not only in the Transvaal, but all over the world. Indeed, the Government of the Commonwealth of Australia and many private individuals are now carrying out investigations on somewhat similar lines to my own, and one can only hope and trust that legislation will result. So far as the Union of South Africa is concerned there is every prospect that legislation bearing on the question of ventilation will be introduced at an early date, as the report of "The Mining Regulations Commission" (Transvaal), which has just been issued, has awakened the public conscience to a sense of its duty. Matters cannot now remain as they were and it must be the bounden duty of all those who have taken an active part in the investigations on which that report is based to see that they are not allowed to remain so. The writer is very much gratified to record that one of our own sister societies, the Chemical, Metallurgical and Mining Society of South Africa, has identified itself enthusiastically with the subject, and, through the medium of its journal, has kept all those interested fully informed of the latest developments.

It is not my purpose in this paper to say anything about the methods employed to determine the very small quantities of carbon monoxide and other components of mine gases, as these have been dealt with fully elsewhere,† but I would merely say that further research has not disclosed any improvements on them. The investigations on the gases themselves are not complete even yet, but the work now in hand is of a confirmatory nature and it is not anticipated that any of the conclusions which have been arrived at will be upset.

Until quite recently it was assumed that a small quantity of nitric peroxide (so-called nitrous fumes) was produced at every blast. This gas has been responsible for the loss of hundreds of human lives in the Transvaal and elsewhere, for its poisonous effects are now well known; but it is gratifying to record that it is seldom produced in practice at all and need hardly ever be if ordinary care and common sense are exercised. It is invariably produced, and in very large quantity, when the explosive is *burned*, and this happens only when care and common sense are absent. Within the past few months the Rand has been aroused from its lethargic interest in this topic by a series of disastrous "gassing" accidents, which involved the loss of scores of lives, but it has been satisfactorily established in every case that some explosive has been ignited through carelessness. For the sake of illustration, let

* See Report S. A. Assn. for Adv. of Sc., Grahamstown, 1908, pp. 63–66,
† Chemical, Metallurgical and Mining Society's Proceedings.

me give a few figures concerning the gases produced by burning explosives:—

TABLE I.—Absolute quantities of nitric oxide found in the gases resulting from the burning of the following nitro glycerine explosives :—

		Per cent.
1.	Ordinary blasting gelatine	33·46
2.	Antifume blasting gelatine	29·23
3.	Blasting gelatine containing chlorate ..	33·27
4.	Gelignite ordinary..	21·00
5.	Gelignite modified..	19·58
6.	Gelatine dynamite	25·00

TABLE II.—Volumes of nitric oxide produced by the burning of one $1\frac{1}{4}$ in. cartridge (about 250 gr.) of the following nitro glycerine explosives :—

		Litres.		cub. ft.
1.	Ordinary blasting gelatine ..	80·68	=	2·845
2.	Antifume blasting gelatine ..	70·42	=	2·487
3.	Blasting gelatine containing chlorate	80·15	=	2·830
4.	Gelignite ordinary	50·59	=	1·787
5.	Gelignite modified..	47·17	=	1·666
6.	Gelatine dynamite	60·23	=	2·127

"These figures call for no particular comment. Those of Table 2 are just the same as Table 1, but put another way.

"What the experiments have made us realise is that with all nitro glycerine explosives tremendous quantities of nitric oxide are produced on burning. The inference is so very obvious that one need hardly dilate upon it, but some inventors have actually gone the length of endeavouring to develop the potential power of nitro glycerine explosives by burning to start with, than which no more efficient method of killing those underground could be devised. One tiny $\frac{7}{8}$ in. cartridge of blasting gelatine can produce enough nitric oxide to kill many people. Experts who have made a special study of the toxic effects of this gas will be able to translate our figures, but as in the case of carbon monoxide—only much more so—they can only be described as astounding."*

Then the invariable presence of carbon monoxide in the explosion gases of blasting gelatine seemed difficult to account for in view of the well-authenticated fact that this explosive in the steel bomb yielded only carbonic acid, water, nitrogen and a small amount of oxygen—in other words confirmed theory. The experiments which led to the solution of the problem are worth recording. Firstly, it was ascertained beyond doubt that the gases from blasting gelatine invariably contained carbon monoxide, as has just been stated. Secondly, it was discovered that the addition to blasting gelatine of an oxidising body, such as a nitrate or chlorate, practically eliminated carbon monoxide, pointing to a deficiency of oxygen in the explosive as used, for it must be remembered in this connection that explosives are contained in paper wrappers, so that these latter become part and parcel of the explosive. This naturally led to trying the explosive without the wrapper, when it was found, thirdly, that theoretical results were obtained, *i.e.*, no carbon monoxide. This seemed so interesting that metallic wrappers, such as tin foil, were substituted for the paper, when confirmatory results were obtained, *i.e.*, again no carbon monoxide. It was clear, therefore, that the paper wrapper accounted for the presence of carbon monoxide.

* Proceedings of the Chemical, Metallurgical & Mining Society, September, 1909.

Although the explosive alone contained a slight excess of oxygen it did not contain enough to oxidise all the carbonaceous matter of the wrapper; hence the partial oxidation and consequent production of carbon monoxide. This discovery, which looks small and unimportant, led to the introduction of a new class of explosive, which has been a great boon to miners who have to work in places where the ventilation is bad. Some people still believe that oxidising mixtures, "outwith" the explosives for which there are many patents, prevent the formation of noxious gases such as carbon monoxide, but the results which I have obtained show that they have no influence one way or another.

At the close of my last paper on this subject I ventured to say:—

> "That to my mind the removal of carbon monoxide by efficient means of ventilation is the most pressing problem which Rand Mining Engineers have to face and once its importance is realised and effective measures are taken to deal with it the health of the miners will be greatly improved."

I am glad to record that these semi-prophetic words have borne fruit. A start has been made, and one or two mines, but notably those of the East Rand Proprietary Mines, are now thoroughly well ventilated. This particular group first of all had the mine gases thoroughly examined—a gas analysis survey was made. Those places at which the ventilation, as indicated by the results, was bad, were carefully noted and special steps were taken to increase the supply of fresh air at these points.

It does not come within the scope of this paper to describe the system of ventilation adopted, but that it has done all that was expected can be shown by the following quotation:—

"Samples were taken from the bottom of three shafts, viz., the Farrar, No. 1 shaft (Driefontein), and the main shaft (Angelo). In all these shafts sinking was proceeding. The average results for these points were as follows:—

$$CO_2 = 0.552\ \%$$
$$CO = 0.011\ \%$$

"After the ventilation scheme was in operation samples were again taken from these points, and the following average results obtained:—

$$CO_2 = 0.149\ \%$$
$$CO = 0.006\ \%$$

"It will be noted that these figures do not represent the average for the mine. The average figures for the mine, however, were:—

First.—before the adoption of the ventilation scheme:—

$$CO_2 = 0{\cdot}493\ \%$$
$$CO = 0{\cdot}012\ \%$$

Second.—After the adoption of the ventilation scheme:—

$$CO_2 = 0{\cdot}127\ \%$$
$$CO = 0{\cdot}005\ \%$$

"Recent samples taken from the air drift at the Angelo upcast directly after blasting, when the vitiation of the air should be at its worst, gave the following results: $CO_2 = 0{\cdot}182\ \%$ and $CO = 0{\cdot}001\ \%$ The temperatures have been reduced by from 2° to 3°.

"The capital expenditure on the installation for the whole property, including fans and motors, erection of same, equipment of up-cast shafts, bratticing, doors, pipes, etc., was about £25,000.

"The cost is insignificant compared to the valuable results obtained, and under the circumstances some system of artificial ventilation should be adopted in practically every mine on the Rand. Not only from a health point of view, but from an economical point of view, the £25,000 spent has been repaid us many times over."*

Of course, some mines are much worse in respect of ventilation than others, and some again are very bad, but on account of their short lives it is not worth while to equip them with ventilating appliances. On the whole, however, I do not believe that the mines of the Witwatersrand are worse than those of other parts of the world, and they are certainly better than most. Matters have undoubtedly improved also since the system of doing all the blasting on one shift was adopted—generally the day shift. During the night the mine, being practically empty, has, therefore, a chance of getting filled up with fresh air. To all who are interested in this subject I would strongly recommend a perusal of the report of the Commission, to which I have already referred, and so far as our particular subject is concerned, the following recommendations, if put into effect by legislation, will be the Miners' Magna Charta.

"(*a*) That the legal maximum for noxious CO_2 permissible in mines in the Transvaal be fixed at 8 parts by volume in 10,000 of air.

"(*b*) That an amount of 4 parts of CO_2 by volume in 10,000 of air shall be allowed in addition to the aforesaid maximum as representing innocuous CO_2 normally present in the atmosphere.

"(*c*) That where candles or similar illuminants are in use a further addition of 3 parts of CO_2 by volume in 10,000 of air shall be allowed as representing innocuous CO_2 resulting from the combustion of such illuminants.

"(*d*) That in order to meet, from the point of view of practical administration, difficulties in regard to possible innocuous CO_2 from 'country rock' and other uncertain sources in the mines of the Rand, a further allowance of 5 parts per 10,000 be made, making a total limit of 20 parts of CO_2 per 10,000 of air.

"(*e*) That in the Lydenburg and other districts where there is geologically strong presumptive evidence of a production of ground CO_2, early investigation be undertaken by Government, and that a proper and reasonable allowance be made therefor, the total amount in the mine air not to exceed 1 per cent. by volume."†

With these recommendations I must associate myself in a most wholehearted manner.

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* Proceedings of the Chemical, Metallurgical and Mining Society, "Ventilation and health conditions on the Mines of the Witwatersrand, with special reference to the Ventilation System of the East Rand Proprietary Mines by S. Penlerick, Member.

† Page 266, Vol. I., Final Report, Mining Regulations Commission.

THE DEVELOPMENT OF GOLD EXTRACTION METHODS ON THE WITWATERSRAND.

By Henry Arthur White.

It may be assumed that members of this Association are familiar with the main outlines of the methods employed in extracting the precious metals from the Witwatersrand banket reefs.

A reference to the last paper on this subject will make clear to anyone the underlying principles of the practice then adopted, and these have undergone no considerable change. I refer to the paper read in April, 1903, before this Association by Dr. Caldecott, who, as is well known, has taken a large share in the developments of the last seven years, with which this paper chiefly deals. It will perhaps be useful to take this statement of the facts of 1903 as a base on which to develop the principal features of present-day practice and to follow the same order of treatment of the various processes to be considered.

As it is usually necessary in mining to stope out some quantity of inter-bedded, but valueless, rock, the first operation to be performed is to remove, as far as practicable, all such "waste" from the valuable ore. The use of sorting tables and belts for this operation is still maintained, and in 1909 the average amount of material so discarded was 14·45 per cent. of the total mined, against 14·24 per cent. in 1903. This left nearly twenty-one million tons of ore to be further dealt with. Somewhat more than half of this passed over the screening arrangements to be broken down into one and a half inch cubes in the rock breakers.

There has not been much change in the devices employed for sorting and breaking; and improvement in detail and the use of larger units have been chiefly responsible for the saving effected in cost of operation. In the transport of the crushed ore from the breaking plant to the mill bins, belts have been introduced, where the distance was short, and full-sized railway trucks and engines are employed where the mills are further away, and may be seen in operation at the Simmer and Jack or the Simmer Deep.

It is proposed to use electric haulage on a similar large scale for the new mill being erected at the City Deep, and this is in keeping with the development of electric power utilisation, consequent on the formation of large power companies, whose sole business is the production and distribution of electric energy.

The considerable saving effected by generating electricity in large quantity, by huge machines centred in suitable localities, will ensure that this means of reducing capital expenditure and economy in cost of operation will be rapidly extended in the near future.

Many mills are now driven by electric motors either in large units, driving 100 or more stamps, as at the Angelo, or by means of smaller motors for each 10-stamp battery.

It is now becoming usual to arrange 10 stamps to be driven from one cam-shaft, but the mortar-box for each 5-stamp unit is still retained. Breakage of these cam-shafts is still a constant source of expense and of stoppage, though this has been considerably reduced as a result of careful investigation of the quality of the steel used by means of a microscopic examination and the utilisation of the latest knowledge in production and heat treatment of this metal. It is proposed at the City Deep mill to put an inch hole right through the cam-shaft centre and to supply extra bearings between the cams, in accordance with Mr. Laschinger's designs, in order to obviate breakage as far as possible.

The greatest changes that have taken place in the battery are in the weight of the stamp and the size of the screen used. The average weight of the stamps running in 1903 was about 1,100 lb., and no samp heavier than 1,500 lb. was in operation. The duty, 4·91 tons crushed per stamp per 24 hours, was thus small compared with the average for 1909, which amounted to 6·79 tons. This increase of duty is not only due to the heavier weight of the stamp employed or to the fact that this weight is rendered more effective by concentration near the crushing point by increasing the weight of the head and using shorter stems; it is also due to the fact that, since the introduction of tube mills, it is possible to use a much coarser screen in the mortar-box. The average weight of the stamps now pounding rock within 20 miles of Johannesburg is probably not more than 1,350 lb., but stamps up to 1,800 lb. are now at work, and in the near future a weight of 2,000 lb. will be employed as at the City Deep mill, with a duty as high as 20 tons a day or possibly more, the limit being set by the coarseness of screen employed.

In 1903 a screen mesh of 600 to 1,000 holes to the square inch was usual, and anything coarser than 500 mesh was rare. To-day screens with nine holes to the square inch are actually in use, and the highest efficiency has been determined by the Mines Trials Committee to be correlated with this aperture. The same stamps which give a duty of 5·88 tons with a screen having an aperture of 0·015″ show the high figure of 20·03 tons with the 9-mesh screen, having an aperture of 0·27″. Even this result may be improved by separating from the ore fed to the battery that portion already fine enough to pass the screen employed (about 30 per cent.), so that in future it is possible that a duty of 30 tons per stamp per diem may be fairly common.

It may be pointed out that the present economical limit of nine holes to the square inch is to some extent governed by the diameter of the tube mills employed. The standard size at present is 5 feet 6 inches in diameter, and 22 feet long, but it is possible that in the future tubes of greater diameter may be successfully employed. This will tend to increase the "size of unit," which is a favourable means of decreasing both capital required and working cost, and may render economic the use of even coarser screens. Proceeding on

these lines, a time may come when the stamp mill will be improved entirely out of existence and the heavy rock-breakers employed will be set to crush finely enough to pass directly to the larger tube mills, or rolls might be used for the slight reduction still required.

No signs of such a progress are yet visible, though it appears merely a logical deduction from the success which has attended the efforts of our metallurgists in the direction of improvement in the operation of the tube mill plant, which is growing to be a more significant part of every new mill erected.

Coincident with the increase of coarseness of the pulp leaving the mortar-box is the difficulty of directly amalgamating the product without further crushing, and it is becoming clear that the advantage of removing the apron plates entirely away from the boxes will emphasize its necessity in the near future. This removing of the amalgamating tables from proximity to the mortar-boxes and the relegation of their duty to shaking plates, placed after the tube mills, is contemplated in many mines, though I believe it was first carried into effect at the West Rand Central mill, where it has proved entirely successful. The only possible drawback to this arrangement—that the lighter portion of the crushed ore, called slime, largely evades the tube mill shaking plates—can be obviated by special arrangement as proposed for the 600-stamp mill being erected at Randfontein. At the City Deep new plant the shaking-plates are placed under the same roof as the extractor-boxes of the cyanide plant, an arrangement which enables all gold recovered to be superintended and handled, till it is in smelted bars for the banks, in one building.

The tube-mill is of course the principal novelty in the history of the reduction plant since Dr. Caldecott's paper was read in 1903, though he foreshadowed it when he wrote advocating the finer crushing of the coarse and pyritic portions of the mill pulp.

Mr. Denny first advocated the use of the tube-mill for this purpose in this country, and referred to its successful use in Australia by Dr. Diehl.

At first introduced cautiously, after careful observation of its performance and of the improvement in extraction shown after the finer crushing obtained by its means, it is now used almost universally, not only on account of this increased extraction of the gold, but also because it has been proved here to be, in conjunction with the heavier stamps and coarser screens, a much cheaper method of reducing ore to the fineness demanded by economic considerations.

An endeavour has been made, on purely theoretic grounds, to show that the crushing efficiency of the tube-mill is only one-fourth of that of the stamp battery, but it is certainly true that its exended use is always accompanied by lower cost for reducing the ore to the utmost fineness now considered economically sound. Thus one or two tube-mills were at first employed for every 100 stamps running, but at the end

of 1909 158 tubes were in use, against 9,545 stamps erected, and it must be observed that there are many mines, whose "lives" are now too short for the re-payment of the necessary capital expenditure, where no tube-mills are yet put up, and that the present tendency is in the direction of one tube to every 15 or 20 stamps; it is possible that the future will see even this proportion of tube-mills increased.

A change of some importance has been made in the method employed for elevating the pulp leaving the mill for classification and subsequent treatment. Formerly tailing-wheels were almost universally employed, though even seven years ago plunger pumps were successfully used in one or two cases. The great disadvantage of the tailing-wheel, beside its high capital cost, was total lack of elasticity when the introduction of improved appliances demanded an increase in the total elevation necessary.

After considerable experimenting, a type of centrifugal pump, with cheap and easily-renewable wearing parts, was found suitable for elevating to any required height the coarsest material yet produced, and many are now in operation. Though the wearing parts may last only 20 or 30 days, the total cost, including capital redemption, of elevating pulp is less than by any other method, and any increase in elevation subsequently required is easily arranged by adding a length of pipe to the delivery column and suitably increasing the speed of the motor. One disadvantage which can, however, be overcome without very great difficulty is the lack of regular flow from the pump if the amount of pulp to be lifted is varied by hanging up stamps or from other causes. This lack of regularity interferes considerably with the effectiveness of any arrangement for classifying the pulp and separating the coarser and heavier portions as is required for their different treatments.

The use of compressed air in the "Pohle lift" is quite effective for elevating pulp, as at the East Rand Mines, and though the efficiency is low, a similar method is largely used, where the aerating effect is also of value in the solution of gold, as in "Brown" agitators or similar apparatus.

The method of separation by means of cones has in the last seven years largely displaced the use of the spitzlutte and spitzkasten, formerly chiefly employed for this purpose, and the introduction, by Dr. Caldecott, of a diaphragm partition near the bottom of the cone enables a much steadier and more uniform product to be returned to the tube-mill plant for regrinding and increases the efficiency of the apparatus for other separations required. The underflow may be thus arranged to retain even less water than is found suitable for the best tube-mill work, so that a second set of cones for removing the excess water may now be dispensed with, and any required adjustment may be accurately made by adding the amount of water experiment has shown to be requisite. A further advantage is found in the increased size of discharging nozzle that may be used when diaphragms are suitably employed; this

avoids the frequent choking up by small pebbles of the smaller nozzles necessarily employed with less efficient arrangements.

The increased efficiency of the cone used in place of an inverted pyramid is largely connected with the fact that it is always arranged to overflow all round the circumference, thus ensuring greater tranquility for settlement and a smaller height of overflow. The spitzkasten has been invariably used with an overflow over one edge only, though of course it would be quite simple to arrange it to be used, similarly to the cone, with central inflow and baffle, and overflow over all four sides, where only wood is available for construction material, and in some other cases such an arrangement would present considerable advantages.

It has always been understood that successful treatment of crushed ore by cyanide solutions depended not only upon the ultimate fineness attained, but also upon the completeness of the separation of the leachable sand from the finer slime which tends to clog up the material to be percolated and to render the access of the air required more difficult.

By the older methods, still largely in use, it is found impracticable to separate sand containing less than 3 to 5 per cent. of slime, and even this efficiency is rarely attained. This difficulty is incidentally largely obviated in the method of collection by means of the Caldecott table. This appliance consists of a slowly-moving table with a peripheral band from one to three feet wide, upon which the thick pulp, containing less than 30 per cent. of moisture as separated at the underflow of a deep cone provided with a diaphragm, is allowed to fall. This band is provided with a filter-bottom, under which a vacuum is maintained by suitable air and water pumps. By these means the excess moisture is sucked out, and the dried material, with about 12 per cent. or less water, is continuously removed by a plough-scraper just before the point where the new material is being deposited. A few inches of sand are allowed to remain to assist the filtering medium, and this has to be removed at intervals when cleaning is necessary. The overflow of the separating cone employed carries away the greater portion of the slime, but in some cases a second cone is employed in which the underflow of the first is washed in clean water, and by this means less than 1 per cent. of slime is allowed to remain with the sand. The clean sand removed from the table is washed by means of a stream of weak cyanide solution to a centrifugal pump, and thus delivered to the collecting vats through Butters distributors, a large portion of the gold getting dissolved in transit. The treatment of the charge may be completed in this collecting vat, as is done at the East Rand Mines, but some little advantage is found in transfering it to one of a series of second treatment vats as at the Simmer and Jack and elsewhere.

The advantages gained in the cleanness of the sand and the fact that it is in contact with cyanide solution a few minutes after being crushed enable a considerable saving in capital expenditure to be made in the vat capacity required. Inci-

dentally also an increase in the tonnage of slime separated this way, which may amount to 8 to 12 per cent., permits a saving in working cost due to the fact that slime can be more cheaply treated than sand.

It is probable, as the greater part of the advantages of this method of collection are really due to the increased efficiency of separation, that its principles will be more largely availed of in the future, either by increased use of the whole apparatus or by other means of dealing with the same problem.

A radically different method of solving this problem of most economic treatment of the crushed ore is that being tried at the East Rand Mines under the name of the Arbuckle Process. This involves the treatment of the pulp as a whole without separation of slime from sand, and thus soves that difficulty by the method of evasion. The pulp, mixed with about three times its weight of weak cyanide solution, is agitated by means of compressed air in deep vats with conical bottoms, circulation being maintained by means of the "Pohle" air-lift principle. About 20 hours is required for a sufficient solution of the gold, when the whole pulp and solution are transferred to an ingenious separating apparatus, the solid portion with as little as 25 per cent. moisture is sent to a further apparatus in order to wash out all the dissolved gold, and the clean solutions are sent to the precipitation plant.

The possible drawbacks are extra cost for power for air compression, and for the mechanical arrangements involved, and the inherent defect that the light slime, which really needs only about one hour's treatment, must remain, undergoing needless circulation for the full time required by the most refractory portions of the ore. The general decrease in working costs, owing to larger units, greater skill in handling material and other important reasons, render it probable that in future this method, perhaps modified in the direction of greater simplicity in the mechanical details, which promises lower capital cost for plant, which is very suitable for the finer grinding, gradually coming into the region of practical economy, and which evades the difficulty of successful percolation with extremely fine sand, will in this country become of as great importance as very similar methods in other parts of the world. It is possible that, as in Australia and elsewhere, some method of mechanical filtration may be found suitable for extracting the dissolved gold from the material treated, and already on these fields the vacuum filter is undergoing successful trial at the Crown Mines, where, however, it is in use for handling slime only. It is yet too early to form an opinion as to whether the more compact apparatus will affect the abolition, from future plants, of the enormous vats now used for the slime decantation process. It is certainly generally felt among metallurgists that the large and expensive plants used for treatment of slime by the standard process offer tempting opportunities in the matter of reduction of capital cost, but so far it is the general experience that a more than countervailing increase of working cost is

involved. When it is considered that a shilling will cover all cost by the standard methods, on the large scale now usual, with an extraction of 85 to 89 per cent. of the total gold, it is clear that the field for economy, either by increasing extraction, where residues are now worth 1s. per ton or less, or in decreasing working cost, is not a wide one. The fact must also be borne in mind that in all feasible methods so far suggested the large vats employed for collection of the slime are still necessary, and even those for solution of the gold are either still required or a more expensive treatment in smaller vessels must be substituted.

With reference to the precipitation of the gold from the working solutions, it may at once be remarked that little change has been made during the last seven years. As, however, this work is performed at a cost of less than one penny per ton and as the value is brought so low as 0·01 dwt., here again the field of future economy is restricted. Experiments have been made with zinc dust, in place of zinc shavings, and the result obtained so far promise economy of space, decrease in capital cost and greater security of the bullion produced. Certain difficulties in the clean-up may possibly be evaded, and it is this weak point in our present methods that leads to the pious hope that in the future the plan of using zinc dust and filter presses may have a brighter prospect.

A glance at the whole series of improvements effected in the past few years will render evident the fact that progress has been almost entirely in the domain of mechanics, and that nearly all proposals for the future emphasise the reduction in capital cost, and in some cases this is pressed so far as to partly ignore the fact that the increased working cost involved is more than counterbalancing. The origin of this state of things can no doubt be referred to the fact of the demonstrated economy in providing a much greater ratio of reduction capacity to mine area, and to the fact that much larger areas are now worked under one company. These facts combine to render necessary very huge capital sums, and all possible means of reducing the amounts necessary are so much the more welcome.

The most interesting question at the present time refers to the disposal of the residue after extraction of the gold has been pushed to its economic limits. Up to the present time nothing has been proposed or done with the slime but store it in dams, where it is useless, unbeautiful, and a source of expense. The coarser portion of the pulp, that is the sand, is now being sent back direct to the mine at the Simmer and Jack, which pioneered this improvement, and at several mines in the Central Rand sand is being removed from the old dumps and sluiced into the worked-out stopes below. This method of sand-filling was inaugurated this year at the Village Deep, and the success obtained is causing the adoption of similar methods on many of our leading mines. The disadvantages of using old residue for this purpose are the double handling of material involved and the expense of supplying lime to neutralise the large amount of acid and acid salts generated

after long exposure to the atmosphere. On the other hand, when using sand directly from the treatment vats, the cyanide present must be effectually destroyed in order to avoid generation of prussic acid gas in the underground workings. It is fortunate that several methods of performing this work are now available. Dr. Moir and Mr. Gray have suggested the use of sulphate of iron and an alkali, and if this method is found sufficiently safe in practice it will cost an insignificant amount for the chemicals necessary. At the Simmer and Jack permanganate of potash has been found to completely destroy the cyanide, so far as even delicate indicators can determine, at a cost of about one penny per ton, and experiments with an alkaline solution of bleaching powder, which promises even lower cost, are now being made.

It is certain that by some of the means suggested above it is perfectly feasible to solve the question of direct return of the sand to the mine, but at the present moment there is little hope of rendering the slime available for underground support, and though the future may see the disappearance of the dismal, dusty sand dump, the permanent presence of the unsightly slime-dam seems an assured feature of the landscape of the Witwatersrand.

Since so little progress, except in details, has been made in the chemical side of our work it is much to be deplored that we have no University in this State where the research work, so necessary for imparting life to the dull routine of teaching, and so urgent for a correct understanding and development of the practice of gold solution and recovery, can be carried on; and it is to be hoped that this defect may in a short time be remedied.

In conclusion, the interesting observation may be made that in no period of its history in the past has so long a vista been possible as now of the future life of these, the most important goldfields yet discovered in this world.

THE DARWIN MEDAL.—At the anniversary meeting of the Royal Society, which was held on the 30th November, the President, Sir Archibald Geikie, K.C.B., D.Sc., made the following reference to the 1910 biennial award of the Darwin Silver Medal.

"To Mr. Roland Trimen, who was for many years curator of the South African Museum in Cape Town, the Darwin medal has been awarded. His official position, and the duties it involved, enabled him to do admirable work in African zoology. His name will always stand with those of Bates and Wallace in the establishment and illustration of the theory of mimicry. In addition to his researches on that subject, he has done admirable systematic work, his descriptions of insects, especially the *Lepidoptera rhopalocera*, being models of accuracy and literary style. He, furthermore, rendered the greatest assistance to Charles Darwin, especially in his work on orchids—assistance the high value of which is acknowledged in a long series of that great naturalist's published letters."

LE VERRIER'S THEORY OF THE MOTION OF THE PLANETS JUPITER AND SATURN.

By Robert T. A. Innes, F.R.A.S.

This theory and the tables based on it are printed in vols. X., XI. and XII. of the *Annales* of the Paris Observatory. It is founded directly on Lagrange's variation of constants. The tables furnish the instantaneous values of the six elements instead of the three co-ordinates actually required. For this reason their use is arduous. Besides this the error of the tables, considering their age, is large and irregular. The tables for Saturn are to be replaced by others by Mons. Gaillot, who has revised or completed the theory of Saturn.

A later and more successful theory for these planets, which will be referred to later on, is due to Dr. Hill.

At its sitting of 7th December, 1908, the French Academy of Sciences fixed for the Damoiseau prize of £80 in 1911 the following: "To perfect Le Verrier's *Tables of Jupiter*."

Le Verrier's tables of Jupiter are used in the *Connaissance des Temps*; Hill's in the *Nautical Almanac*, the *American Ephemeris*, and the *Berliner Jahrbuch*.

The following table shows the reduction which must be applied to the heliocentric ephemeris in the Connaissance des Temps to reduce it to that of the Nautical Almanac, or in other words to reduce Le Verrier's places to Hill's. The last two columns show the corrections to the Nautical Almanac indicated by places derived from photographs taken at the Greenwich Observatory.*

Opposition.		Long.	Lat.	log r.	Mean Date.	R.A.	Dec.
						s.	
1908.	Jan. 29	+14″·8	+0″·6	+ 7	1908·3	—0·110	—0″·72
1909.	Feb. 28	+16″·0	+0″·8	+ 3	1909·3	—0·163	—1″·14
1910.	Mar. 31	+15″·7	+1″·2	+13	..	..	..
1911.	May 1	+13″·9	+1″·0	+16	..	..	..
1912.	June 1	+ 9″·3	+0″·7	+ 9	..	..	..

Hill's tables represent the longitude of Jupiter in 1908–9 within 2″, whilst Le Verrier's error is about 13″.

The perturbations in Hill's tables have been computed by Hansen's method, which furnishes directly the three co-ordinates required. If the perturbations depending on the second and higher products of the masses are at all important, the formulæ of the variation of elements become remarkably involved; Hansen had drawn attention to this point and to the advantage his methods offer, so long ago as 1831†: and when it is a mere matter of getting tables to give a major planet's position during several centuries, Hansen's methods are better than any other, although they have not perhaps every advantage that has been claimed for them. In his latest theories of Uranus and Neptune, Newcomb adopted

* See Mon. Notices R.A.S., Vol. LXVIII., p. 585, and Vol. LXIX., p. 676.

† Untersuchung uber die Gegenseitigen Störungen des Jupiters und Saturns, Berlin, pp. XIV.-XV.

Hansen's methods and no one had a more extensive practical know ledge of all methods of computing perturbations. The aim of the earlier perturbational astronomers such as Lagrange and Laplace, was to develop theories which would furnish a unique set of tables based on a literal development which would be available for thousands of years. That such a result is not impossible is proved by their theory of Jupiter's Galilean satellites. The lunar theory may also be cited as a sufficient solution of the same problem. Le Verrier's work on Jupiter and Saturn had the same end in view, but it was not reached and it is safe to say never will be reached by his road. The circumstances which favour the solution in the cases of Jupiter's satellites and in the lunar theory are absent in the theories of the eight major planets: in the first case the eccentricities and mutual inclinations are exceedingly small; in the second, the eccentricity and inclination do not vary, and the ratio of distances is very small. All this is well-known; it is recognised that the attack must be directed differently. So far as merely obtaining an ephemeris goes, it is probable that the method of special perturbations would have given one for 300 years or so with less labour than was involved in either the theories of Hill or Le Verrier. But a mere numerical exhibit is not what is wanted. A theory, good for ages, in which t alone has to be substituted will be the aim of the astronomer-mathematician. Le Verrier's attempt to arrive at this end by means of variation of elements failed, but this failure does not account for the errors of his tables. The mean distances in the planetary theories are so nearly constants that as early as possible their numerical ratios are introduced into the formulæ, and thus each ratio becomes, as it were, the backbone of the theory. It is in this fundamental point that Le Verrier has made a considerable error. The value of the ratio (which as usual will be designated by α) for Jupiter and Saturn adopted by Le Verrier is too large and in consequence all the perturbating coefficients are too big. To a certain extent, this error can be compensated by reducing the masses of these two planets. In the introduction to his theory, Hill says:

> "The motions assigned to the excentricity and perihelion of Saturn in Le Verrier's tables are considerably greater than those given by my theory. In the case of Jupiter, Le Verrier's values of the coefficients of the large terms are quite as large as mine, although they profess to correspond to the value 1/3529·6 of the mass of Saturn, while mine have been computed with the mass 1/3501·6. This, perhaps, explains why Le Verrier's discussion led him to the too small mass of Saturn."*

Unfortunately, the relation between α, m and m', is not linear, so that a good adjustment is impossible and the resulting theory must remain faulty.

This paper deals with the value of α which should be used and gives the values of the b functions appearing in the expansion of the perturbing function; then some of the secular perturbations are computed and compared with Le Verrier's results; lastly, the great inequality of Jupiter by Saturn and some other large inequalities are computed to the first power of the masses. The

* Papers of Amer. Eph. IV., p. 18.

comparisons show that the 3rd and 4th figures of the perturbations found by Le Verrier are erroneous. So as to make the comparisons just, the only difference made is in the value of a and a' and the resulting value of α. Although Le Verrier started with erroneous values of a and a', it is to be remarked that his tables contain the constant perturbations which make the tabular distances from the Sun nearly exact.

As already stated, the foundation of Le Verrier's theory of Jupiter and Saturn is the value of α, the ratio of the mean distances of the planets. In all the formulæ given by Le Verrier allowance for changes, secular and otherwise, in any of the elements is made with the single exception of this ratio. As will be shown at once, the value for this ratio adopted by Le Verrier is largely in error and his whole theory is thereby vitiated. The mean distances of the planets are always determined indirectly through the mean motions. In a purely elliptic theory the equation connecting the quantities is

$$a^3 n^2 = f\,(1 + m)$$

but this equation does not hold in the case of three bodies such as the Sun, Jupiter and Saturn. In perturbed motion, constant (or very nearly constant) quantities are added to both a and n. Laplace, in his celebrated *Mecanique Celeste,* uses the simpler equation $a^3 n^2 = f$; but in the cases of Jupiter and Saturn, the m part is added.* But Laplace in the theory of Jupiter's Satellites goes further,† and in fact gives equations by which the true values of the a's can be determined.§ This matter is also dealt with very clearly by Tisserand.‡ Le Verrier was not ignorant of these corrections to the elliptic values, for he states :

"These corrections which are to be applied to the values of the semi-axes majores are too small to have any influence upon the calculation of the coefficients of the perturbations."||

On pp. 187 and 189 of the same volume, he gives the "corrections" to the semi-axes deduced from the apparent motion, but it is well to remark that there will still remain the constant parts of the perturbations of the radii-vectores. Newcomb and Hill give the expressions which should be adopted.**

A tabular exhibit of some of the most important values of log α previously adopted will be interesting. It will be very obvious that only one of the values given can be correct.

			Log. α.	
XI.	Laplace	..	9·7366493.	*Mec. Cel.*, IV., p. 86.
1831.	Hansen	..	9·7367384.	Jupiter and Saturn, p. 66.
1874.	Le Verrier	..	9·7367408.	Annales, X., p. 17.
1890.	Hill	..	9·7365514.	Jupiter and Saturn, p. 21.
1895.	Harzer	..	9·7359957.	Säc. Verand, p. 87.
1898.	Newcomb	..	9·7365514.	Tables of Uranus, p. 295.

* See Tome, III., pp. 139 and 150.
† T., IV., p. 86.
§ See T. IV., pp. 13 and 86.
‡ Mec. Cel. T. IV., p. 18.
|| Tome, X., p. 8.
** See Newcomb, *Orbit of Uranus*, p. 31; Hill, T. III., *Jupiter and Saturn*, p. 20.

The only approximately correct value is that given by Hill and adopted later by Newcomb. Hansen introduces the correction to a in his computation of terms depending on the second and higher powers of the masses and Le Verrier could also have done so, but did not. Harzer's valne is evidently derived from corrected mean motions but it overlooks the partially compensating correction to the mean distances. Newcomb is not everywhere consistent,—thus in computing the secular perturbations of the inner planets he uses values of the mean distances which practically reproduce Le Verrier's value of a; but it should be added that the errors so introduced are very small. The greatly erroneous value of a used by Harzer, seriously damages his work and will account, in part at least, for the discordance to which Hill has already drawn attention.* It is to be remarked that the interesting conclusions as to the motions of the perihelia of Jupiter and Saturn, drawn by Hill in the just-quoted paper, being based on Le Verrier's value of a will also require considerable modification. In a paper re-published in his Collected Works, Hill draws attention to the differences between the mean distances of Jupiter and Saturn according to the methods of Laplace and Hansen (T. II, pp. 85-86). But I quote from a letter which Dr. Hill kindly wrote me (30th April, 1907):—

"My exact values for Hansen are given in the Introduction to my tables. They are:

Hansen, log. $a = 0{\cdot}7162373716$. log. $a' = 0{\cdot}9794957103$.

"Apply to these the corrections to Laplace's formulæ and they become:

Laplace, log. $a = 0{\cdot}7162374665$. log. $a' = 0{\cdot}9794965529$.

"If the constant of precession is changed these numbers also undergo a change, but this is minute.

"I hardly think anyone would care for Hansen's a at present. Laplace's form is to be preferred in almost all investigations. These values of the a are derived from the mean motions which prevail at epoch 1850. But as far as the Laplace a is concerned, I do not think the values for 1900 would differ more than a unit in the 10th decimal."

The Laplacian a resulting from Hill's figures is

	$\log(a) = 9{\cdot}7367409136$	to which we add the constant part of the perturbations of the radii-vectores
	$\cdot 0001866830$	from Hill's tables, pp. 28 and 172.
Hence	$\log a = 9{\cdot}7365542306$	

If a has been calculated from the equation $a^3 n^2 = f\ (1+m)$ the reduction to the true a may be found as follows:—

If F denotes the secular part of the elliptic perturbative function then

(a) Action of outer planet on inner

$$\delta \log. a = -\tfrac{1}{3} \frac{m'}{1+m} \mathrm{M}\, a\, \mathrm{D}\, \mathrm{F}$$

(b) Action of inner planet on outer

$$\delta \log. a' = +\tfrac{1}{3} \frac{m}{1+m'} \mathrm{M}\, (1+\mathrm{D})\, \mathrm{F}$$

* Eccentricities . . of Jupiter and Saturn, Coll. Works, T. IV., p. 135.

wherein $M = 0{\cdot}43429\ (9{\cdot}63778)$* and $D = a\dfrac{d}{da}$

and F may be taken =

$$\tfrac{1}{2}\, b_{0,1} + \tfrac{1}{8}\,(e^2 + e_1^2 - 4\,\eta^2)\,(D + D^2)\, b_{0,1}$$
$$+ \tfrac{1}{4}\, e\, e_1 \cos(w - w_1)\,(2 - D - D^2)\, b_{1,1}$$

or with sufficient exactness, more simply

$$\delta \log. a = -\tfrac{1}{6}\, m'\, M\, a\, D\, b_{0,1}. \qquad \delta \log. a' = \tfrac{1}{6}\, m\, M\,(1 + D)\, b_{0,1}.$$

or if the planets are very distant from each other

$$\delta \log. a = -\tfrac{1}{6}\, m'\, M\, a^3. \qquad \delta \log. a' = \tfrac{1}{3}\, m\, M\,(1 + \tfrac{3}{4}\, a^2).$$

The last equation shows us that this effect of an inner planet on a distant outer planet is nearly equivalent to an increase of the Sun's mass by that of the inner planet, viz. :—

$$a^3,\ n^3, = f\,(1 + m + m,).$$

Some elaboration on this point seems necessary as even in so modern a work as Charlier's *Mechanik des Himmels*, 1902, the values of log a given for the major planets are all erroneous.†

The following table exhibits the value of δ log a for each of the major planets. It is mainly due to Newcomb and Hill.

TABLE OF δ LOG a (IN UNITS OF THE 8TH DECIMAL).

	Mercury.	Venus	Earth	Mars.	Jupiter.	Saturn.	Uranus.	Neptune.
Mercury ..	..	+3	+2	+2	+2	+2	+2	+2
Venus ..	—4	..	+63	+43	+35	+36	+36	+36
Earth ..	—2	—19	..	+68	+46	+45	+44	+44
Mars ..	—0	—0	—1	..	+5	+5	+5	+5
Jupiter ..	—3	—19	—51	—192	..	+18244	+14641	+14140
Saturn ..	—0	—1	—2	—9	—502	..	+5135	+4479
Uranus ..	—0	—0	—0	—0	—7	—58	..	+949
Neptune ..	—0	—0	—0	—0	—2	—13	—174	..

The approximate calculation for two cases may be given :—

Mercury by Jupiter.	Logs.	Neptune by Jupiter.	Logs.
$\frac{1}{6}$ =	9·222	$\frac{1}{3}$ =	9·5229
$m,$	6·980	m =	6·9799
M	9·638	M =	9·6378
a^3	6·615	$1 + \frac{3}{4}a^2$ =	0·0097
	n 2·455 = —3		6·1503 = 14136

From the tables of the planets by Newcomb and Hill we get the total δ log a (unit of 8th decimal place).

Mercury	—8	
Venus	—36	
Earth	+11	(Including action of Mercury, omitted by Newcomb.)
Mars	—87	
Jupiter	—408	
Saturn	+18260	
Uranus	+19689	ditto
Neptune	+19655	ditto

* The number in brackets is the logarithm of the preceding number.

† Band 1, Tafel 1, p. 439.

If these numbers are added to a derived from the observed mean motion by means of the elliptic equation, we have :—

	Log a.	
Mercury	9·58782160	Newcomb, Tables
Venus	9·85933745	,, ,,
Earth	0·00000012	,, ,,
Mars	0·18289616	,, ,,
Jupiter	0·71623339	Hill, (Laplace's a)
Saturn	0·97967915	,, ,,
Uranus	1·28309713	Newcomb, Tables
Neptune	1·47814316	,, ,,

(2 has been added in the last place of decimals for the action of Mercury in the cases of Earth, Uranus and Neptune.)

If the correction to log a is neglected so far as concerns the four inferior planets, no harm will be done, because in the case of their largest perturbations, 5 resulting figures will be correct even if Jupiter is the disturbing planet and no perturbation runs into that number; similarly, the perturbations by Saturn are so small that the error is quite negligible. Again, the corrections to log a for Saturn, Uranus and Neptune are so nearly equal that they practically cancel one another in their mutual perturbations. The only important case is that of Jupiter and Saturn, but there is no reason why accuracy should not be maintained throughout.

It should be noted that the values of log a for Uranus and Neptune are not the rigorous mean distances, as the theories are not cleared of the effect of the great long period inequality.

When the above values of log a are used the distances of the planets only deviate from the elliptic values by periodical quantities, and therefore conform to the usual definition of mean elements.

In order to check some of the perturbations used by Le Verrier, it is necessary to compute the Laplacian b coefficients and their logarithmic derivatives. The new formulæ for this purpose which are developed in the 1909 June and December numbers of the Monthly Notices of the R.A.S., make this computation simple, in fact, all the numbers required can be calculated in one day.

The value of log α for which the b's are calculated is 9·7365540 but a linear formula is given later which will allow us to pass to the b's for log $(\alpha+\Delta\alpha)$ quite easily. By the formula on page 648 (M.N.R.A.S. LXIX.) we compute $b_{0,1}$ (noting that in this, as in all cases, the q terms are negligible), we have

$$1+\sqrt{\alpha_{,}} = 1.91559135$$

$$\sqrt[4]{8}\,(\alpha_{,}^{\frac{1}{2}}+\alpha_{,}^{\frac{3}{2}}) = 1.91558955$$

giving $\quad b_{0,1} = 2·18014144. \qquad \log = 0·33848467.$

Then if in $\quad b_{i,1} = \alpha^{i}\, b_{0,1}\; p_1\, p_2\, p_3 \ldots\ldots p_i$

we stop at $b_{11,1}$, we require to find p_{11} by a continued fraction*—here the final terms only are given :—

* See *loc. cit.*, p. 640, or Ast. Papers of the American Ephemeris, Vol. III., p. 64.

co-log.	0·6511	2·32503	0·5965610	3·1227385
Zech.	0·10975	0·002060	0·1267874	0·0003275
constants	8·09211	9·928271	7·2773661	9·9797966
a^2	9·47311	9·473108	9·4731080	..
	7·67497	9·403439	6·8772615	9·9801241

With p_{11} we now proceed to find p_{10}, p_9, etc., by the well-known continuous process.* The calculations *in extenso* for p_{10} and p_9 are as follows :—

p_{11}	9·9801241	p_2	9·8815199
$a^2/1+a^2$	9·3600875		9·3600875
Constant	0·0211893		0·1760913
	9·3614009		9·4176987
Co-log	0·6385991		0·5823013
Zech	0·1134117		0·1317299
Constant	9·9777236		9·6989700
$1/1+a^2$	9·8869795		9·8869795
p_{10}	9·9781148	p_1	9·7176794

The resulting values are :—

	Log.
p_1	9·7176794
p_2	9·8815199
p_3	9·9241391
p_4	9·9440413
p_5	9·9556190
p_6	9·9632065
p_7	9·9685687
p_8	9·9725618
p_9	9·9756519
p_{10}	9·9781148
p_{11}	9·9801241

These values of the p's can be checked by Robbins's table (M.N.R.A.S., June, 1909).

Then

$b_{0,1}=$	0·3384847		0·3384847	
a	9·7365540	β^2	9·6263013	
p_1	9·7176794			
			9·9647860	
$b_{1,1}$	9·7927181	$1/1-p_1$	0·3205819	By Zech direct from p_1
a	9·7365540			
p_2	9·8815199	$Db_{0,1}$	9·6442401	
			etc., etc.	
$b_{2,1}$	9·4107920			
	etc., etc.			

* See Newcomb, Ast. Papers of the American Ephemeris, Vol. III., p. 63.

In this way $b_{i,1}$ and $D\,b_{i,1}$ have been found. The values of p_{12} and p_{13} are easily found by extrapolation, if $b_{12,1}$ and $b_{13,1}$ should be required. The next step is to find $D^m b_{0,1}$ and $D^m b_{1,1}$ to such value of m as may be desired; we chose $m = 8$. The equations are

$$D^2\ b_{0,1} = \beta^2\,[2\,D+1]\,b_{0,1} \qquad \beta^2 = \frac{\alpha^2}{1-\alpha^2}, \qquad \log. = 9.62630129.$$

$$\begin{aligned}
D^3 \ ,, \ &= \beta^2\,[\ 4\,D^2 + \ 5\,D + \ 2]\,b_{0,1}\\
D^4 \ ,, \ &= \beta^2\,[\ 6\,D^3 + 13\,D^2 + 12\,D + 4]\,b_{0,1}\\
D^5 \ ,, \ &= \beta^2\,[\ 8\,D^4 + 25\,D^3 + 38\,D^2 + 28\,D + 8]\,b_{0,1}\\
D^6 \ ,, \ &= \beta^2\,[10\,D^5 + 41\,D^4 + 88\,D^3 + 104\,D^2 + 64\,D + 16]\,b_{0,1}\\
D^7 \ ,, \ &= \beta^2\,[12\,D^6 + 61\,D^5 + 170\,D^4 + 280\,D^3 + 272\,D^2 + 144\,D + 32]\,b_{0,1}\\
D^8 \ ,, \ &= \beta^2\,[14\,D^7 + 85\,D^6 + 292\,D^5 + 620\,D^4 + 832\,D^3 + 688\,D^2 + 320\,D\\
&\qquad + 64]\,b_{0,1}
\end{aligned}$$

and

$$\begin{aligned}
D^2\ b_{1,1} &= \quad b_{1,1} + \beta^2\,[\ 2\,D + 1]\,b_{1,1}\\
D^3 \ ,, \ &= D\ b_{1,1} + \beta^2\,[\ 4\,D^2 + 5\,D]\,b_{1,1}\\
D^4 \ ,, \ &= D^2\,b_{1,1} + \beta^2\,[\ 6\,D^3 + 13\,D^2 + 8\,D]\,b_{1,1}\\
D^5 \ ,, \ &= D^3\,b_{1,1} + \beta^2\,[\ 8\,D^4 + 25\,D^3 + 32\,D^2 + 16\,D]\,b_{1,1}\\
D^6 \ ,, \ &= D^4\,b_{1,1} + \beta^2\,[10\,D^5 + 41\,D^4 + 80\,D^3 + 80\,D^2 + 32\,D]\,b_{1,1}\\
D^7 \ ,, \ &= D^5\,b_{1,1} + \beta^2\,[12\,D^6 + 61\ D^5 + 160\ D^4 + 240\ D^3 + 192\ D^2\\
&\qquad + 64\,D]\,b_{1,1}\\
D^8 \ ,, \ &= D^6\,b_{1,1} + \beta^2\,[14\,D^7 + 85\,D^6 + 280\,D^5 + 560\,D^4 + 672\,D^3\\
&\qquad + 448\,D^2 + 128\,D]\,b_{1,1}
\end{aligned}$$

On the right hand side of these equations the symbols of operation have, for convenience in writing and printing, been separated from those of quantity; thus $\beta^2\,[2\,D+1]\,b_{0,1}$ is to be read $\beta^2\,(2\,Db_{0,1} + b_{0,1})$.

Before proceeding further, it is advisable to check the quantities already found by means of the relations

$$D\,(D-1)^m\,b_{0,1} = \alpha\,D^{m+1}\,b_{1,1}$$

or

$$D^m\,b_{0,1} = \alpha\,D\,(D+1)^{m-1}\,b_{1,1}$$

and this has been done for the table on page 113.

The rest of the $D^m\,b_{i,1}$ quantities can be computed easily and expeditiously with a Brunsviga calculating-machine, as the quantities are simple additions, subtractions and short whole-figure multiplications of the quantities already found.

The formulæ to be used are:

$$\begin{aligned}
b_{0,3} &= (D^2 + D - \ \ 0)\,b_{1,1}\\
b_{1,3} &= (D^2 + D - \ \ 2)\,b_{2,1} = (D^2 + D - \ \ 0)\,b_{0,1}\\
b_{2,3} &= (D^2 + D - \ \ 6)\,b_{3,1} = (D^2 + D - \ \ 2)\,b_{1,1}\\
b_{3,3} &= (D^2 + D - \ 12)\,b_{4,1} = (D^2 + D - \ \ 6)\,b_{2,1}\\
b_{4,3} &= (D^2 + D - \ 20)\,b_{5,1} = (D^2 + D - \ 12)\,b_{3,1}\\
b_{5,3} &= (D^2 + D - \ 30)\,b_{6,1} = (D^2 + D - \ 20)\,b_{4,1}\\
b_{6,3} &= (D^2 + D - \ 42)\,b_{7,1} = (D^2 + D - \ 30)\,b_{5,1}\\
b_{7,3} &= (D^2 + D - \ 56)\,b_{8,1} = (D^2 + D - \ 42)\,b_{6,1}\\
b_{8,3} &= (D^2 + D - \ 72)\,b_{9,1} = (D^2 + D - \ 56)\,b_{7,1}\\
b_{9,3} &= (D^2 + D - \ 90)\,b_{10,1} = (D^2 + D - \ 72)\,b_{8,1}\\
b_{10,3} &= (D^2 + D - 110)\,b_{11,1} = (D^2 + D - \ 90)\,b_{9,1}\\
b_{11,3} &= (D^2 + D - 132)\,b_{12,1} = (D^2 + D - 110)\,b_{10,1}\\
b_{12,3} &= (D^2 + D - 156)\,b_{13,1} = (D^2 + D - 132)\,b_{11,1}\\
b_{13,3} &= (D^2 + D - 182)\,b_{14,1} = (D^2 + D - 156)\,b_{12,1}
\end{aligned}$$

$$
\begin{aligned}
9b_{0,5} &= (D^2+D-0)\,b_{1,3} \\
9b_{1,5} &= (D^2+D-0)\,b_{2,3} = (D^2+D-2)\,b_{0,3} \\
9b_{2,5} &= (D^2+D-2)\,b_{3,3} = (D^2+D-6)\,b_{1,3} \\
9b_{3,5} &= (D^2+D-6)\,b_{4,3} = (D^2+D-12)\,b_{2,3} \\
9b_{4,5} &= (D^2+D-12)\,b_{5,3} = (D^2+D-20)\,b_{3,3} \\
9b_{5,5} &= (D^2+D-20)\,b_{6,3} = (D^2+D-30)\,b_{4,3} \\
9b_{6,5} &= (D^2+D-30)\,b_{7,3} = (D^2+D-42)\,b_{5,3} \\
9b_{7,5} &= (D^2+D-42)\,b_{8,3} = (D^2+D-56)\,b_{6,3} \\
9b_{8,5} &= (D^2+D-56)\,b_{9,3} = (D^2+D-72)\,b_{7,3} \\
9b_{9,5} &= (D^2+D-72)\,b_{10,3} = (D^2+D-90)\,b_{8,3} \\
9b_{10,5} &= (D^2+D-90)\,b_{11,3} = (D^2+D-110)\,b_{9,3} \\
9b_{11,5} &= (D^2+D-110)\,b_{12,3} = (D^2+D-132)\,b_{10,3} \\
9b_{12,5} &= (D^2+D-132)\,b_{13,3} = (D^2+D-156)\,b_{11,3}
\end{aligned}
$$

$$
\begin{aligned}
25\,b_{0,7} &= (D^2+D-2)\,b_{1,5} \\
25\,b_{1,7} &= (D^2+D-0)\,b_{2,5} = (D^2+D-6)\,b_{0,5} \\
25\,b_{2,7} &= (D^2+D-0)\,b_{3,5} = (D^2+D-12)\,b_{1,5} \\
25\,b_{3,7} &= (D^2+D-2)\,b_{4,5} = (D^2+D-20)\,b_{2,5} \\
25\,b_{4,7} &= (D^2+D-6)\,b_{5,5} = (D^2+D-30)\,b_{3,5} \\
25\,b_{5,7} &= (D^2+D-12)\,b_{6,5} = (D^2+D-42)\,b_{4,5} \\
25\,b_{6,7} &= (D^2+D-20)\,b_{7,5} = (D^2+D-56)\,b_{5,5} \\
25\,b_{7,7} &= (D^2+D-30)\,b_{8,5} = (D^2+D-72)\,b_{6,5}
\end{aligned}
$$

$$
\begin{aligned}
49\,b_{0,9} &= (D^2+D-6)\,b_{1,7} \\
49\,b_{1,9} &= (D^2+D-2)\,b_{2,7} = (D^2+D-12)\,b_{0,7} \\
49\,b_{2,9} &= (D^2+D-0)\,b_{3,7} = (D^2+D-20)\,b_{1,7} \\
49\,b_{3,9} &= (D^2+D-0)\,b_{4,7} = (D^2+D-30)\,b_{2,7} \\
49\,b_{4,9} &= (D^2+D-2)\,b_{5,7} = (D^2+D-42)\,b_{3,7}
\end{aligned}
$$

We compute $b_{0,3}$, $b_{2,3}$, $b_{4,3}$, etc., and $D^2 b_{3,1}$, $D^2 b_{5,1}$, etc., simultaneously, then $b_{1,3}$, $D^2 b_{2,1}$, etc., and so on. A type is :—

$$
\begin{array}{lcr}
D^2\,b_{1,1} & = & 1\cdot566782 \\
D\,b_{1,1} & = & 0\cdot808444 \\
\hline
b_{0,3} & = & 2\cdot375226 \\
2\,b_{1,1} & = & 1\cdot240932 \\
\hline
b_{2,3} & = & 1\cdot134294 \\
D\,b_{3,1} & = & 0\cdot395874 \\
\hline
 & & 0\cdot738420 \\
6\,b_{3,1} & = & 0\cdot707353 \\
\hline
D^2\,b_{3,1} & & 1\cdot445773
\end{array}
$$

and so on.

It is by these easy steps that the following table of Laplace coefficients has been made up.

Log. $a = 9.7365540$.

i	$b_{i,1}$	$D b_{i,1}$	$D^2 b_{i,1}$	$D^3 b_{i,1}$	$D^4 b_{i,1}$	$D^5 b_{i,1}$	$D^6 b_{i,1}$	$D^7 b_{i,1}$	$D^8 b_{i,1}$
0 ..	2·18014144	0·4407620	1·294968	4·967250	25·65171	172·7318	1443·960	14423·53	167624·9
1 ..	0·62046606	0·8084444	1·566782	5·168907	26·03478	174·5960	1454·847	14499·13	168269·0
2 ..	0·25750864	0·6022980	1·648449	5·818365	28·09749	181·9227	1490·964	14740·37	170270·0
3 ..	0·11789216	0·3958742	1·445773	6·048271	30·69648	195·8862	1565·667	15214·44	..
4 ..	0·05650413	0·2469112	1·136833	5·679125	31·98802	211·2715	1676·886	15998·17	..
5 ..	0·02781334	0·1495783	0·833630	4·901490	31·16658	220·8666	1795·660	17051·14	..
6 ..	0·01393201	0·0889403	0·582682	3·963261	28·44768	220·1272	1881·700	18171·73	..
7 ..	0·00706539	0·0522022	0·393352	3·046910	24·53304	208·4256	1903·491	19071·18	..
8 ..	0·00361620	0·0303472	0·258638	2·251256	20·17076	188·0175	1848·570	19488·50	..
9 ..	0·00186405	0·0175126	0·166591	1·611256	15·93553	162·4067	1723·018	19273·10	..
10 ..	0·00096633	0·0100473	0·105541	1·123612	12·17515	135·0477	1545·008	18409·09	..
11 ..	0·00050328	0·0057371	0·065963	..	..	..	..	..	..
12 ..	0·00026312	0·0032631	0·040761	..	..	..	..	..	..

i	$b_{i,3}$	$D b_{i,3}$	$D^2 b_{i,3}$	$D^3 b_{i,3}$	$D^4 b_{i,3}$	$D^5 b_{i,3}$	$b_{i,5}$	$D b_{i,5}$
0 ..	2·375226	6·735689	31·20368	200·6308	1629·443	15953·98	4·09791	25·4447
1 ..	1·735730	6·262217	30·61896	198·3835	1616·692	15867·49	3·68766	24·2626
2 ..	1·134294	5·118800	28·07012	190·2930	1577·373	15604·79	2·94076	21·2699
3 ..	0·705695	3·853026	24·02516	175·1100	1504·302	15139·80	2·17526	17·4375
4 ..	0·426941	2·743554	19·39548	154·0034	1393·195	14429·47	1·52936	13·5638
5 ..	0·253662	1·877734	14·93049	129·6770	1248·397	13449·62	1·03675	10·1214
6 ..	0·148808	1·247772	11·05917	104·9884	1081·529	12220·80	..	..
7 ..	0·086478	0·810450	7·93831	82·1179	907·025	10808·09	..	..
8 ..	0·049892	0·516939	5·55225	62·3317	738·066	9302·84	..	..
9 ..	0·028619	0·324896	3·80008	46·0978	584·293	7799·81	..	..
10 ..	0·016340	..	..	..	..	..	..	..
11 ..	0·009292	..	..	..	..	..	..	..
12 ..	0·005268	..	..	..	..	..	..	..

To test the accuracy of these figures, use has been made of the equation

$$D^m\left(D+\iota-\frac{n-1}{2}\right)b_{\iota,n}=\alpha\,(D+1)^m\left(D+\iota+\frac{n-1}{2}\right)b_{\iota-1,n}.$$

This affords a complete test, because it connects even and odd values of $D^m b_i$, whilst the method of calculation keeps these quite separate.

In particular we have $(D+3)\,b_{5,5}=\alpha\,(D+7)\,b_{4,5}$, or $13{\cdot}2316=\alpha\times 24{\cdot}2693=13{\cdot}2316$, thus $D\,b_{4,5}$ is correct, hence $D^3\,b_{5\cdot3}$ is correct, and its correctness implies that $D^5\,b_{6\cdot1}$ and all lower orders are correct.

Then $(D^5+8\,D^4)\,b_{9,3}=\alpha\,(D^5+14\,D^4+46\,D^3+64\,D^2+41\,D+10)\,b_{8,3}=12474{\cdot}15$ being exact, ensures that all the quantities to $D^7\,b_{8,1}$ are exact.

It is possible that the value of α adopted ($\log = 9{\cdot}7365540$) may require alteration. If so, as already stated, it will not be necessary to recompute the coefficients *de novo*, because we have

For $(\alpha+\Delta\alpha)$ For α

$$D^m\,b_{i,n}=D^m\,b_{i,n}+\log.\left(1+\frac{\Delta\alpha}{\alpha}\right)\;D^{m+1}\,b_{i,n}+\tfrac{1}{2}\left[\log.\left(1+\frac{\Delta\alpha}{\alpha}\right)\right]^2 D^{m+2}\,b_{i,n}+\&c.$$

(see M.N.R.A.S. LXIX, p. 647, where, however, $p!$ has been misprinted for $1/p!$).

If the correction to $\log\alpha$ is less than 0·0000434 the first and second right-hand terms need only to be retained, to secure accuracy to seven places of decimals. It will be understood that $\log\left(1+\frac{\Delta\alpha}{\alpha}\right)$ is a natural logarithm.

If $\Delta\log\alpha=\pm\,0{\cdot}0000434$, a value which can hardly be exceeded, we have

$$\log\left(1\pm\frac{\Delta\alpha}{\alpha}\right)=\pm\,0{\cdot}0001000$$

and

$$\tfrac{1}{2}\left[\log\left(1\pm\frac{\Delta\alpha}{\alpha}\right)\right]^2=+\,0{\cdot}0000000{,}05$$

or more generally

$$\log\left(1\pm\frac{\Delta\alpha}{\alpha}\right)=\pm\,2{\cdot}3026\,\Delta\log\alpha.\quad(0{\cdot}36222).$$

It is to be remarked that these incremental factors depend on $\Delta\alpha$ and are independent of the actual value of α.

With these formulæ, a comparison with Le Verrier's values of the coefficients becomes easy and one or two examples may be given. As Le Verrier used $\log\alpha=9{\cdot}7367408$, we have $\Delta\log\alpha=+0{\cdot}0001868$ and

$$\log\left(1+\frac{\Delta\alpha}{\alpha}\right)=0{\cdot}000{,}4301{,}2\qquad(6{\cdot}63359).$$

$$\tfrac{1}{2}\left[\quad\text{ditto}\quad\right]^2=0{\cdot}000{,}0000{,}9\qquad(2{\cdot}966)$$

Then

$$\text{L.V.'s } b^{(0)}=2{\cdot}1801414+\left\{\begin{matrix}Db_{0,1}\\0.4407\end{matrix}\right\}\times 0{\cdot}0004301=1895$$

$$2{\cdot}180331\quad\text{in perfect agreement.}$$

$$\text{L.V.'s } b_1^{(9)} = 0{\cdot}4407620 + \begin{Bmatrix} D^2 b_{0,1} \\ 1{\cdot}2950 \end{Bmatrix} \times 0{\cdot}0004301 + \begin{Bmatrix} D^3 b_{0,1} \\ 4{\cdot}96 \end{Bmatrix} \times \ldots 9 \Big\}$$

$$\begin{array}{r} +\quad 5575 \\ \hline 0{\cdot}4413195 \end{array} \quad \text{in perfect agreement.}$$

$$\text{L.V.'s } b_1^{(10)} = 0{\cdot}0100473 + 0{\cdot}1055 \times \text{etc.}$$

$$\begin{array}{r} 454 \\ \hline 0{\cdot}010093 \end{array}$$

where Le Verrier has 0·010083; in this case Le Verrier is undoubtedly in error, because we find that Runkle's tables for log α=9·7367410 give 0·010096.*

It is not without interest to compare the secular part of the elliptic disturbing function and this is done in the annexed table.† The first, third and fifth figure-columns give the values of the coefficients for log α = 9·7367408, the second, fourth and sixth for log α = 9·7365540. Logarithms of the numbers are given.

The columns headed $a' R_1$, $a' a \frac{d R_1}{d a}$ etc., show Le Verrier's figures; those headed F, DF, etc., the new figures. As will be gathered $a' R_1$=F, the latter being Newcomb's symbol. To get $a' a \frac{d R_1}{d a}$ etc., Le Verrier has had a long and arduous work, which is evaded by using the "D" operator. Many of the coefficients are closely related and afford immediate checks, which however were only very incompletely known to Le Verrier. Thus $(b) = 4\ (a)$, a condition only satisfied by one pair of Le Verrier's figures; $(g) = 4\ (e)$, $(j) = 8\ (f)$, and $(l) = 8\ (d)$, conditions which are also not rigorously fulfilled. Then the calculation of many of the coefficients can be greatly abbreviated on the forms of both Newcomb and Le Verrier, thus $(a) = \frac{1}{8}\ b_{1,3}$; $(c) = \frac{1}{4}\ b_{2,3}$; $(e) = -\frac{9}{32}\ b_{0,5}$; $(i) = -\frac{9}{64}\ b_{2,5}$; $(k) = \frac{9}{8}\ b_{1,5}$; $(m) = -\frac{225}{256}\ b_{0,7}$; to quote only a few. The same simplifications hold with D and (1 + D) which is indeed obvious enough in Newcomb's notation, but it is hidden in Le Verrier's . Le Verrier's second and third columns for the coefficients (h) are entirely erroneous.

Secular Inequalities.

The effect of the second and higher powers of the masses so modifies all but the lowest terms of the secular variations that a comparison of the lowest terms will suffice. The terms added by the higher powers of the excentricities are in several cases increased 100-fold by including the second powers of the masses in the mutual perturbations of Jupiter and Saturn.

Secular variation of the epoch :—this is not of much importance in the present theory ; we have

		Le Verrier	Term in
$\frac{d\varepsilon}{dt} =$	$-7''{\cdot}46858$	$-7''{\cdot}48126$	
	$-0{\cdot}14440$	$-0{\cdot}14476$	$e_2 + e_{\prime 2}$
	$+0{\cdot}01270$	$+0{\cdot}01273$	n_2
	$+0{\cdot}02399$	$+0{\cdot}02406$	$ee_\prime \cos(\tilde{\omega}' - \tilde{\omega})$.

* Runkle, New Tables, p. 54.

† See next page.

PERTURBING FUNCTION: SECULAR PART (Le Verrier, X., p. 68).

	$a' R_1$	F	$a' a \frac{d R_1}{d a}$	D F	$a' a' \frac{d R_1}{d a'}$	$-(1+D)$ F	Notes.
1	+ 0·0374925	+ 0·0374547	+ 9·3437236	+ 9·3431741	— 0·1175450	— 0·1174210	
$e^2+e^2_1$	+ 9·3370663	+ 9·3363922	+ 9·8945526	+ 9·8936381	— 0·0007507	— 9·9998885	(*a*)
η^2	— 9·9391263	— 9·9384522	— 0·4966117	— 0·4956981	+ 0·6028101	+ 0·6019485	(*b*)
$e e_1 \cos(\tilde{\omega}^1 - w)$	— 9·4535088	— 9·4526658	— 0·1081333	— 0·1071082	+ 0·1950272	+ 0·1940350	(*c*)
e^4	+ 9·07904	+ 9·0775881	+ 9·9702	+ 9·9685230	— 0·02269	— 0·0210431	(*d*)
$e^2 e^2_1$	+ 0·06282	+ 0·0616547	+ 0·8562	+ 0·8546902	— 0·92100	— 0·9195416	(*e*)
e^4_1	+ 9·75320	+ 9·7521957	+ 0·4841	+ 0·4827972	— 0·55812	— 0·5568639	(*f*)
$e^2 \eta^2 + e^2 \eta^2$	— 0·66487	— 0·663715	— 1·4582	— 1·456750	+ 1·52300	+ 1·521602	(*g*)
η^4	+ 0·62199	+ 0·620783	+ 0·6220	+ 1·432323	— 0·92302	— 1·494654	(*h*)
$e^3 e_1 \cos(\tilde{\omega}^1 - w)$	— 9·85698	— 9·855658	— 0·7066	— 0·70496	+ 0·76403	+ 0·762430	
$e e^3_1$,, ...	— 0·15588	— 0·154720	— 0·9507	— 0·94930	+ 1·01531	+ 1·013937	
$e e_1 \eta^2$,, ...	+ 0·90507	+ 0·903831	+ 1·7279	+ 1·72682	— 1·78874	— 1·787636	
$e^2 e^2 \cos 2(\tilde{\omega}^1 - w)$	+ 9·61787	+ 9·616522	+ 0·4774	+ 0·47583	— 0·53361	— 0·532069	(*i*)
$e^2 \eta^2 \cos 2(w - \tau^1)$	+ 0·65629	+ 0·655285	+ 1·3872	+ 1·38589	— 1·46121	— 1·459954	(*j*)
$e e_1 \eta^2 \cos(\tilde{\omega}^1 + w - 2\tau^1)$ ..	— 0·61913	— 0·617903	— 1·4376	— 1·43609	+ 1·49901	+ 1·497538	(*k*)
$e^2_1 \eta^2 \cos 2(\tilde{\omega}^1 - \tau^1)$	+ 9·98213	+ 9·980678	+ 0·8731	+ 0·87161	— 0·92562	— 0·924134	(*l*)
e^6	+ 8·97531	+ 8·973043	..	..	..	..	
$e^4 e^2_1$	+ 0·37251	+ 0·370573	..	..	..	..	
$e^2 e^4_1$	+ 0·79499	+ 0·793345	..	..	..	..	
e^6_1	+ 0·22667	+ 0·225267	..	..	..	..	
$e^5 e_1 \cos(\tilde{\omega}^1 - w)$	— 9·97025	— 9·96814	..	..	..	..	
$e^3 e^3_1$,, ...	— 0·87679	— 0·87498	..	..	..	..	(*m*)
$e e^5_1$,, ...	— 0·79252	— 0·79096	..	..	..	..	
$e^4 e^2_1 \cos 2(\tilde{\omega}^1 - w)$	+ 0·16195	+ 0·15996	..	..	..	..	
$e^2 e^4_1$,, ...	+ 0·55529	+ 0·55355	..	..	..	..	
$e^3 e^3 \cos 3(\tilde{\omega}^1 - w)$	— 9·82939	— 9·82746	..	..	..	..	

Secular variation of the Perihelion :—the two largest terms are

		Le Verrier.
$\frac{dw}{dt} =$	7″·344302	7″·358876
	—1·141011	—1·143720
	6.203291	6·215156

Inclination and Node :—Le Verrier introduces a quantity Φ (*Les Annales*, X., p. 188) for the lowest term of which he gives —1·1683473, whereas it should be —1·1676732, if the new value of a is adopted.

The calculation of the secular variation of the excentricity is given in more detail. It will be seen that a slight modification occurs in the coefficient of e', in so far as the first powers of the masses are concerned.

The chief figures for $\frac{1}{\cos\psi}\frac{de}{dt}$ are as follows :—

Log K = 1·2290342 (1·2292210 Le Verrier).

		Le Verrier.	
e'	0″·269063	0″·269702	
$e^2 e'$	1584	1589	
e'^3	4248	4261	
$e' \eta^2$	—910	—913	
$e^4 e'$	5	5	
$e^2 e'^3$	52	52	
e'^5	58	58	
	+0·274100	+0·274754	× sin $(\tilde{\omega}'—w)$
	+0·268290	+0·268930	
	—2193	—2203	× sin 2 $(\tilde{\omega}'—w)$
	—879	—883	

The final results are

	+0″·268290	+0″·268930
	— 879	— 883
	— 11	— 11
	+ 668	+ 670
	+ 230	+ 230
	+0·268298	+0·268936
Reduction for cos ψ	—313	—313
$\frac{de}{dt} =$	+0·267986	+0·268623

A reference to *Les Annales* XI, pp. 28 and 43, will easily identify each step shown.

Periodic Inequalities.

In the periodic part of the perturbing function, the comparison of the coefficients of $(l' - \lambda)$ is as follows :*

$$
\begin{array}{llll}
 & & & \text{Le Verrier} \\
a' \, R_{(0,1)} & = & 8 \cdot 876613 & 8 \cdot 87727 \\
a' \, a \dfrac{d \, R_{(0,1)}}{d \, a} & = & 9 \cdot 420363 & 9 \cdot 42109 \\
a' \, R_{(1,0)} & = & -0 \cdot 4383544 & -0 \cdot 4378412 \\
a' \, a \dfrac{d \, R_{(1,0)}}{d \, a'} & = & -0 \cdot 6806245 & -0 \cdot 6804551
\end{array}
$$

The periodic perturbations of Jupiter which are due to the first power of the mass of Saturn will be found on pp. 127-142 of Vol. X of *Les Annales*. The most interesting of these is the great inequality in longitude. We give on successive lines, the value due to our and to Le Verrier's value of a. Le Verrier's other figures are adopted unchanged. It should, however, be stated that Le Verrier's figures have also been recomputed, and in some cases, a quite trifling difference has been found ; hence in a few cases Le Verrier's figures as given here, differ slightly from those given in *Les Annales*. The symbols almost explain themselves, β and β' serve to indicate the powers of the excentricities of Jupiter and Saturn which enter into the numerical values. Terms of the fifth order which involve the mutual inclination of the two planets' orbits have been omitted.

$$
\begin{array}{lllll}
 & -\ 135''\cdot 61 \, \beta^3 & +0''\cdot 36 \, \beta^5 & +\ 6''\cdot 16 \, \beta^3 \beta'^2, & \times \sin (5 \, l' - 2 \, \lambda - 3 \, w) \\
\text{Le V.} & -\ 136 \cdot 00 & +0 \cdot 36 & +\ 6 \cdot 36 & \\
 & +\ 789 \cdot 78 \, \beta^2 \beta', & -1 \cdot 98 \, \beta^4 \beta', & -15 \cdot 04 \, \beta^2 \beta'^3, & \times \sin (5 \, l' - 2 \, \lambda - \tilde{\omega}' - 2 \, w). \\
\text{Le V.} & +\ 791 \cdot 33 & -1 \cdot 99 & -15 \cdot 06 & \\
 & -1521 \cdot 42 \, \beta \beta'^2, & +3 \cdot 58 \, \beta^3 \beta'^2, & +15 \cdot 12 \, \beta \beta'^4, & \times \sin (5 \, l' - 2 \, \lambda - 2 \, \tilde{\omega}' - w). \\
\text{Le V.} & -1524 \cdot 51 & +3 \cdot 57 & +15 \cdot 14 & \\
 & +\ 967 \cdot 34 \, \beta'^3, & -1 \cdot 84 \, \beta^2 \beta'^3, & -\ 5 \cdot 59 \, \beta'^5, & \times \sin (5 \, l' - 2 \, \lambda - 3 \, \tilde{\omega}'). \\
\text{Le V.} & +\ 968 \cdot 90 & -1 \cdot 84 & -\ 5 \cdot 36 & \\
 & -\ \ 7 \cdot 913 \, \beta \, \eta^2 & & & \times \sin (5 \, l' - 2 \, \lambda - w - 2 \, \tau'). \\
\text{Le V.} & -\ \ 7 \cdot 939 & & & \\
 & +\ \ 17 \cdot 728 \, \beta' \, \eta^2 & & & \times \sin (5 \, l' - 2 \, \lambda - \tilde{\omega}' - 2 \, \tau'). \\
\text{Le V.} & +\ \ 17 \cdot 780 & & &
\end{array}
$$

In computing these, Newcomb's development of the perturbing function has been used and it will not be without interest to exhibit the formulæ. The first of the six parts of which the great inequality is made up involves the ratio of the semi-axes, the excentricities and mutual inclination as follows :—

$$e^3 \, P^{3,0}_{3,0} + e^5 \, P^{5,0}_{3,0} + e^3 \, e'^2 \, P^{3,2}_{3,0} + \text{etc.}$$

in which

---

* Les Annales, X., p. 72.

$$P^{3,0}_{3,0} = -\tfrac{1}{48}\,(380+152\ D+21\ D^2+D^3)\times$$
$$[1+\sigma^2\,\{25-D-D^2\}+\sigma^4\{25-D-D^2\}\ \{27-D-D^2\}+\&c.]\ b_{5,1},$$

but here, as already stated, the terms factored by powers of (*sine* of semi-inclination) are omitted.

The chief term of the second part is $e^2e,\ P^{2,1}_{2,1}$ and so on.

With the above limitation we have :—

$$\begin{aligned}
P^{3,0}_{3,0} &= -\tfrac{1}{48}\ (380+152\ D+21\ D^2+D^3)\ b_{5,1}\\
P^{2,1}_{2,1} &= +\tfrac{1}{16}\ (396+161\ D+22\ D^2+D^3)\ b_{4,1}\\
P^{1,2}_{1,2} &= -\tfrac{1}{16}\ (402+169\ D+23\ D^2+D^3)\ b_{3,1}\\
P^{0,3}_{0,3} &= +\tfrac{1}{48}\ (389+176\ D+24\ D^2+D^3)\ b_{2,1}\\
P'^{1,0}_{1,0} &= -\tfrac{1}{4}\ (\ 6+D)\ b_{4,3}\\
P'^{0,1}_{0,1} &= +\tfrac{1}{4}\ (\ 9+D)\ b_{3,3}
\end{aligned}$$

$$\begin{aligned}
P^{5,0}_{3,0} &= +\tfrac{1}{768}\ (11840+\ 5796\ D+\ 812\ D^2-\ 31\ D^3-16\ D^4-D^5)\ b_{5,1}\\
P^{4,1}_{2,1} &= -\tfrac{1}{192}\ (10728+\ 4990\ D+\ 539\ D^2-\ 77\ D^3-19\ D^4-D^5)\ b_{4,1}\\
P^{3,2}_{1,2} &= +\tfrac{1}{128}\ (\ 8844+\ 3852\ D+\ 205\ D^2-128\ D^3-22\ D^4-D^5)\ b_{3,1}\\
P^{2,3}_{0,3} &= -\tfrac{1}{192}\ (\ 6224+\ 2427\ D+\ 181\ D^2-184\ D^3-25\ D^4-D^5)\ b_{2,1}
\end{aligned}$$

$$\begin{aligned}
P^{3,2}_{3,0} &= +\tfrac{1}{192}\ (38000+14820\ D+1568\ D^2-\ 73\ D^3-22\ D^4-D^5)\ b_{5,1}\\
P^{2,3}_{2,1} &= -\tfrac{1}{128}\ (33334+12745\ D+1087\ D^2-134\ D^3-25\ D^4-D^5)\ b_{4,1}\\
P^{1,4}_{1,2} &= +\tfrac{1}{192}\ (27348+10276\ D+\ 545\ D^2-200\ D^3-28\ D^4-D^5)\ b_{3,1}\\
P^{0,5}_{0,3} &= -\tfrac{1}{768}\ (20267+\ 7575\ D-\ \ 49\ D^2-271\ D^3-31\ D^4-D^5)\ b_{2,1}
\end{aligned}$$

(N.B. $P^{2,3}_{0,3} = -\tfrac{1}{4}\,(16-D-D^2)\ P^{0,3}_{0,3}$ $\quad P^{3,2}_{3,0} = -\tfrac{1}{12}(100-D-D^2)\ P^{3,0}_{3,0}$

The values of the logarithms of the coefficients are :—

		Le Verrier.
$P^{3,0}_{3,0}$	—0·064713	—0·06578
D P,,	—0·820707	—0·82185
—(1+D) P,,	0·890889	0·89202
$P^{5,0}_{3,0}$	0·11538	0·11617
$P^{3,2}_{3,0}$	1·22499	1·23832
$P^{2,1}_{2,1}$	0·7635112	0·7643927
D P,,	1·4270555	1·43806
—(1+D) P,,	—1·5123454	—1·52157
$P^{4,1}_{2,1}$	—0·79395	—0·7944
$P^{2,3}_{2,1}$	—0·54551	—1·5460
$P^{1,2}_{1,2}$	—0·9822612	—0·982959··
D P,,	—1·554250	—1·555067
—(1+D) P,,	1·657343	1·65813
$P^{3,2}_{1,2}$	0·97863	0·97872
$P^{1,4}_{1,2}$	1·48125	1·48175
$P^{0,3}_{0,3}$	0·7193942	0·719908
D P,,	1·1589648	1·159654
—(1+D) P,,	—1·2935999	—1·29425
$P^{2,3}_{0,3}$	—0·62583	—0·6248
$P^{0,5}_{0,3}$	—0·98216	—0·9642
$P'^{1,0}_{1,0}$	—0·122642	—0·12390
D P′,,	—0·952512	—0·9539
—(1+D) P′,,	1·01244	1·0138
$P'^{0,1}_{0,1}$	0·406722	0·4078
D P′,,	1·16660	1·1678
—(1+D) P′,,	—0·23620	—1·2375

The largest individual coefficient in the great inequality is composed of three terms, viz. :—

	Le Verrier.
$-1545''\cdot514$	$-1548''\cdot66$
$+\ \ 25\ \cdot821$	$+\ \ 25\ \cdot88$
$-\ \ \ 1\ \cdot728$	$-\ \ \ 1\ \cdot73$
$-1521\ \cdot421$	$-1524\ \cdot51$

The other coefficients have been built up in the same way but it is needless to present the details.

The largest periodic perturbation of the mean longitude of Jupiter which is independent of the excentricities, is given by the equation

$$\delta l = \mathrm{B}\frac{1}{\nu-1}\left(\tfrac{3}{2}\frac{\mathrm{N}}{\nu-1} - a\frac{d\,\mathrm{N}}{d\,a}\right)\sin 2\ (l'-\lambda)$$

wherein

$$\tfrac{3}{2}\frac{\mathrm{N}}{\nu-1} - a\frac{d\,\mathrm{N}}{d\,a}$$

may be replaced by

$$\tfrac{3}{2}\frac{1}{\nu-1}\,b_{2,1} + \mathrm{D}\,b_{2,1}$$

In this case the effect of the error in a is trifling, viz.,

$$\delta l = 66''\cdot890 \sin 2\ (l'-\lambda). \quad (\text{Le V. } 66''\cdot992.)$$

The inequalities depending on the term

$$-\tfrac{1}{2}e\ (4+\mathrm{D})\ b_{2,1}\ \cos\ (2l'-\lambda-\varpi)$$

compare as follows :—

		Le Verrier.
δa	$-\ 67''\cdot335$	$-\ 67''\cdot436$
δe	$+133\ \cdot99$	$+134\ \cdot19$
δl	$-128\ \cdot681$	$-128\ \cdot883$

In the case of Saturn disturbed by Jupiter, there is a great inequality depending on the mutual elongation ; it compares as follows :—

		Le Verrier.
δa_1	$6933''\cdot286$	$6922''\cdot179$
δl_1	$534\ \cdot865$	$534\ \cdot487$

The part depending on β^2 in $\delta l'$ was also computed and found to be $-0''\cdot52$ agreeing with Le Verrier.

The above comparisons are sufficient to show that the fourth significant figure always and often the third significant figure in Le Verrier's values of the periodical perturbances are incorrect. As was to be expected, Le Verrier's values are invariably too large, so that his theory, compared with observations, would necessarily lead him to assign values of the masses which are too small.

ANOTHER VIEW OF EDUCATION IN PRIMARY SCHOOLS.

By GILBERT FREDERICK AYERS.

(*Not printed.*)

AURORA AUSTRALIS.—Mr. C. Stewart, B.Sc., Secretary of the Cape Meteorological Commission, contributes to the *Quarterly Journal of the Royal Meteorological Society* (October, 1910, pp. 384—386) an account of various apparitions of the Aurora Australis in South Africa during the last forty years. He mentions, apropos of Mr. Stead's observation of the aurora at Bloemfontein in September 1909 (see Vol. 6 of this Journal, p. 68), that similar displays have been witnessed in South Africa in an even lower latitude than that of Bloemfontein, namely, at the Vaal River Diggings, in latitude 28° 30′ south. The display alluded to occurred on the 23rd and 24th October, 1870, and on the 24th and 25th of that same month a splendid display of auroral light was visible in England. That occurrence was described by Dr. R. J. Mann in a note printed in the *Proceedings* of the Meteorological Society (Vol. 5, p. 281). Mr. Stewart takes occasion to draw attention to a letter of Mr. E. J. Stone, who was Sir David Gill's predecessor as Astronomer Royal at the Cape, which was published in *Nature* of April 4, 1872, and described an aurora of unusual splendour, which was seen at the Royal Observatory in the Cape Peninsula, and as far north as Bloemfontein, on the 4th February, 1872, and far surpassed in brilliance the phenomenon observed fifteen months earlier. Simultaneously with the display of southern lights recorded by Stone, a magnificent aurora borealis was witnessed over a zone extending from Siberia and Greenland as far south as Bombay, Syene (Upper Egypt), and Florida. The southern aurora was likewise seen at the same time in Australia and Mauritius. Mr. Stewart also quotes Angot's reference to no less than 34 auroras recorded at Hobart, Tasmania, between 1841 and 1848, everyone of which was contemporaneous either with similar auroral displays in Europe, or (if in the day time) with important magnetic perturbations in the northern hemisphere. An auroral display was noted at Port Elizabeth on May 15, 1871, and from one to five days later in various parts of Europe.

KARROO SOIL, LUCERNE AND THE OSTRICH FEATHER.

By Professor Paul Daniel Hahn, M.A., Ph.D., and the late Donald Sinclair Stevenson.

The first analyses of soils in the Cape Colony were made in 1879 and 1880. These investigations were, however, limited to vineyard soils in the south-western part of the Colony. The results revealed the fact that there was a remarkable difference in the principal features of the vineyard soils of the coast districts and the inland districts. The former, mostly stiff clays, which were formed by the disintregation of metamorphic slate, of granite, or of both, are poor, very poor, in lime, but do not require irrigation during the summer season, whereas the vineyards of the inland districts are on a porous, loose loam, which is fairly calcareous; the grapes in these vineyards do not come to perfection unless the ground has been irrigated two or three times during the summer season. These investigations were made in connection with the work of the first Phylloxera Commission. The report of this Commission includes an interesting sketch-map showing the districts of the Colony which had clay and lime soils.

After the establishment of the Agricultural Department the analyses of the soils in the agricultural districts of the Colony was vigorously taken up by Dr. C. F. Juritz, who published in 1909 the results of his own and his associates' labours in one volume, the study of which is most instructive. It is an excellent work and full of valuable information. I only regret that the matter of the book is not arranged according to some scientific principle, such as the geological structure of the country, but in alphabetical order of the districts. It so happens that the report on the soils of the Oudtshoorn district is followed by the report on the soils of the Paarl district. I recommend to the reader the study of these two reports and the analyses given, which show in a striking manner the contrast which exists between the two principal kinds of soil of the Colony: the stiff clay soil, formed from clayslate, or granite, or both, and poor in lime and other plant-food, and the loose Karroo soil—frequently an alluvial soil—abounding in plant-food and particularly in calcareous constituents.

On the former we have frequently the sour veld, and on the Karroo soil the sweet veld. There are of course many varieties of each of these principal soils, and in a dry climate like ours "brack" plays an important part in the composition of the soils.

The farmer in the Karroo district attaches much importance to the occurrence of the Mimosa or Thorn-Tree (*Acacia horrida*), which is a sure indication of rich and deep soil. If we examine the composition of the mineral ingredients of this tree we come to the conclusion that it can only grow on a

soil well supplied with all the essential constituents of plant food. The air-day Mimosa wood* consists of:—

Moisture	7·65 %
Organic constituents ..	88·25 %
Ash	4·09 %

And again the ashes contain:—

Silica	5·21 %
Oxide of Iron	13·78 %
Calcic Oxide	31·85 %
Magnesic Oxide	10·36 %
Potassic Oxide	22·66 %
Phosphoric Oxide	5·39 %

These figures show that the Mimosa is a lime and potash eater of the first order, that it can thrive only on a rich calcareous soil, and that the ashes of the Mimosa wood are an excellent fertiliser for flower and vegetable gardening.

The productive power of the Karroo soil is known throughout South Africa, and does not require further comments. It is the ideal soil for such crops as lucerne, which demand a deep, loose soil with a large supply of lime, potash and phosphoric oxide.

This is well illustrated by the following figures compiled from "Chemie der Pflanzen," by Ebermayer.

From one acre of land the quantities stated below are taken on an average by one crop of each of the following plants:—

	Phosphoric Oxide.	Calcic Oxide.	Potassic Oxide.
Lucerne ..	39 lbs.	186 lbs.	108 lbs.
Tobacco	30 ,,	121 ,,	65 ,,
Potatoes ..	29 ,,	31 ,,	110 ,,
Peas	22 ..	39 ,,	47 ,,
Wheat	21 ,,	8 ,,	32 ,,

Surely such facts must convince us that it is futile to attempt the cultivation of lucerne on the sour, stiff clay soils of the coast districts of the Western Province without previously transforming them by "liming" into a suitable soil for lucerne.

In addition to the valuable mineral ingredients, lucerne contains also a large proportion of albuminous compounds and fat. Of all the fodder plants which we cultivate, lucerne contains the largest proportion of albuminous constituents, and it is worth remembering that one pound of lucerne hay contains more albuminous compounds than one pound of fresh fowl eggs. It is therefore a bone and muscle producer, which has not its equal among the fodder crops which we cultivate for green and stable feeding.

The lucerne also contains fat, which has a sweet, pleasant, honey-like smell. This fat is uniformly distributed throughout the system of the whole plant, and not limited to the leaves or flowers; it can be extracted from the stalks as well as from the leaves and flowers.

* Most of the analyses given in this paper were made by the late Donald Stevenson, son of Sir Edmund Stevenson, M.D. Mr. Stevenson had devoted nearly 18 months to the investigations which he hoped to embody in a paper, which he intended reading at the meeting of the South African Association for the Advancement of Science this year. I deeply lament the untimely death of my young friend and assistant, whose work is of such importance that it should be made known. I hope that it will be continued by other students of Bio-Chemistry, who will follow up this work with the same enthusiasm and devotion as our departed friend.

In all the numerous agricultural experimental stations in Europe and the United States are well-equipped chemical laboratories, in which continuously bio-chemical research is carried on, the results of which, turned to use and applied in practical agriculture, are in the first place responsible for the advanced state of all matters agricultural in those parts of the world.

In sunny South Africa, with its enormous tracts of land suitable for agriculture, we have two or three Experimental Agricultural Stations without chemical laboratories or with chemical laboratories inadequately equipped, in which no bio-chemical research of any kind is carried on. Is it to be wondered that we are in the dark and remain in the dark as to many questions bearing on the production of crops and feeding of animals which are of the utmost importance to our farmers? We may not apply here in South Africa the results of research carried on under other climatic conditions without modifications, but we do not know how far and in what way these results must be modified. In illustration of this I may refer to the fact that the percentage of nitrogenous constituents of plants greatly depends upon the sunshine which the crops and plants generally had during their period of vegetation. The Cinchona trees in the hothouses of Kew contain no quinine, whereas in their sunny home on the tropical Andes they produce large quantities of quinine. The Hemlock grown on the sunny coast of the Mediterranean is full of the poisonous nitrogenous Coniine, whereas the Hemlock grown in the Shetland Islands and in Norway is eaten with impunity by cattle and is quite harmless.

Similar observations have been made in connection with the production of albuminous constituents in crops cultivated in a cold, cloudy, and in a warm, sunny climate.

The late Mr. Stevenson made analyses of three samples of lucerne procured through the kindness of Dr. Melle, Robertson. The following results are taken verbatim from the papers left by Mr. Stevenson:—

	No.	1	2	3
	Nature of soil.	Konings River silt and detritus from surrounding hills.	Red Karroo soil, experimental farm, Robertson.	Cogman's Kloof soil.
Percentage of Lucerne.	Moisture	13·62	16·14	13·87
	Ash	7·70	9·04	9·16
	Organic matter	78·67	74·82	76·96
	Nitrogen	2·31	2·37	2·19
	Albumenoids	15·03	15·41	14·29
	Wax	—	1·52	—
Percentage of Ash.	Total carbon dioxide ..	21·42	21·39	21·65
	Total sulphuric oxide ..	3·75	4·27	—
	Silica	6·56	7·48	4·35
	Oxide of Iron and alumina	12·35	13·82	11·89
	Phosphoric oxide	7·26	7·47	7·89
	Lime	12·53	11·64	12·50
	Potash	29·65	31·03	28·41
	Soda	—	15·96	—

In all these analyses whole lucerne plants were taken, leaf and stalk together, so as to arrive at a good average. Each of the figures in the above analyses indicates the average of at least two determinations and in most cases more.

One season's crop would take from one acre of soil:—

No.	1	2	3
Phosphoric Oxide	67 lbs.	80 lbs.	86 lbs.
Lime	115 lbs.	126 lbs.	137 lbs.
Potash	274 lbs.	336 lbs.	312 lbs.

It will be noticed from the three analyses that the phosphoric oxide is pretty constant, and also that the variation in percentages in most of the other constituents is very slight. The three crops may be said to be chemically almost the same.

These researches of the late Mr. Stevenson yield very interesting results:—

(*a*) The growth of lucerne in our sunny climate is much more vigorous than in the moderate climate of Europe, and consequently the amount of mineral constituents, phosphoric oxide, lime and potash, taken from the soil is very much larger than in Europe.

(*b*) The average amount of albumenoids in our lucerne is larger than in the lucerne grown in Europe, and our lucerne-hay is more nutritious than the lucerne-hay from Germany or England.

Although lucerne was brought to the Colony only about 50 years ago, it is now the staple-fodder in the Karroo-soil districts, and an important branch of farming—ostrich farming—entirely depends upon lucerne and flourishes on lucerne.

Many observant ostrich farmers have noticed that there is a considerable difference between the feathers of the wild ostrich, the veld-fed bird, and the lucerne-fed bird. Mr. Stevenson undertook with great devotion a large number of analyses of ostrich feathers, the results of which those readers will particularly appreciate who have some experience of Zoo-chemical analyses. The following are the results of these researches as I find them amongst the papers of my late young friend.*

* We are greatly indebted to the firm of Messrs. Wm. Spilhaus and Company, Cape Town, who most liberally supplied Mr. Stevenson with all the material which he required for his research. Mr. Spilhaus deserves the hearty thanks of ostrich farmers as well as of all others who are interested in these investigations, because they could not have been undertaken unless the very large number of different feathers from the various parts of the country had been put at our disposal free of costs.

OSTRICH FEATHER ANALYSES.

No. 1.—Feathers of Lucerne-Feh Birds.

Class of Feather.	Measurement in cms.	Ash in Quill.	Ash in Beard.	Moisture and Organic matter.	Remarks.
		%	%	%	
Cock, white	48 × 28	2·35	1·17	98·24	Feather barred. Quill strong, pithy. Flue soft, flossy.
Femina	54 × 26	2·73	1·51	97·89	Quill strong, pithy. Flue soft.
Femina	39 × 17	2·53	1·76	97·86	Quill strong, pithy, soft flue.
Cock (tail)	37 × 20	1·70	2·23	98·03	Feather barred, fine quill.
Cock (blacks)	33 × 20	1·11	1·54	98·68	Very flimsy feather, weak quill hardly self-supporting.
Hen (drabs)	44 × 18	1·68	2·28	98·02	Fine quill, wiry flue.

No. 2. Feathers of Veld-Fed Birds.

Class of Feather.	Measurement in cms.	Ash in Quill.	Ash in Beard.	Moisture and Organic matter.	Remarks.
Cock (white)	52 × 21	2·85	1·95	97·60	Strong, thick pithy quill, barred, harder flue.
Cock (black)	40 × 17	1·39	2·32	98·15	Fine quill. Flue stiffer than in case of Lucerne.
Hen (tails)	42 × 19	1·36	2·10	98·27	Fine quill. Wiry flue.
Hen (drabs)	..	1·85	2·94	97·61	Wiry flue.

No. 3. Wild Birds form Bushmanland.

Class of Feather.	Measurement in cms.	Ash in Quill.	Ash in Beard.	Moisture and Organic matter.	Remarks.
Cock (white)	79 × 13	..	..	..	Very thick pithy quill. Flue narrow and coarse. Diameter of quill = 0·6 cms.
Femina	73 × 13	2·28	1·61	98·06	Do. Diameter of quill = 0·5 cms.
Hen (drabs)	48 × 21	2·12	2·54	97·67	Finer quill. Coarse wiry flue.
Cock (black)	38 × 20	1·97	2·46	97·79	Do. do.

	Lucerne-fed birds.	Veld-fed birds.
Average percentage of Ash :		
In quill	2·02	1·86
In beard	1·75	2·33
In whole feather	1·94	2·04
Nitrogen determinations :		
Number of analyses ..	11	5
Maximum percentage ..	13·31	13·63
Minimum percentage ..	11·16	12·60
Average	12·21	13·03

SULPHUR DETERMINATIONS.

I. Lucerne-fed birds :		II. Veld-fed birds :	
Cock, white ..	3·21 %	Cock, White ..	2·49 %
Femina ..	3·35 %	Cock, white ..	2·32 %
Cock, tail ..	3·02 %	Cock, white ..	2·23 %
Cock, blacks ..	3·05 %	Cock, blacks ..	2.24 %
Average ..	3·16 %	Average.. ..	2·32 %

ANALYSES OF ASH.

	Silica.	Oxide of Iron.	Alumina.	Phosphoric Oxide.	Lime.	Magnesia.
I. Lucerne-fed birds ..	17·36	4·93	13·48	10·00	15·69	15·84
II. Veld-fed birds	20·45	5·60	9·95	12·98	13·53	8·84
III. Wild birds ..	22·06	9·02	8·33	13·65	12·53	7·56

The principal constituent of the ostrich feather is Keratine, which can be prepared in great purity from hair, horn, nails. It is of a somewhat complex composition and the formidable symbol C_{461} H_{762} N_{140} O_{154} S_{12} is assigned to it.* The percentage of sulphur, however, varies considerably: In human hair it ranges from 3·83 per cent. to 8·23 per cent. It is remarkable that six ostrich feathers analysed by Mr. Stevenson do not vary in the percentage of sulphur of feathers of the same kind. Thus the feathers of the lucerne-fed bird contain a larger proportion of sulphur than the feathers of the veld-fed bird. On examining the above results of analyses it will be further observed that the feathers of the lucerne-fed bird contain less inorganic constituents, and in these there is a smaller amount of Silica than in the feathers of the veld-fed bird and the wild bird.

It is not safe to construct a theory on the basis of *one* series of investigations only, it will be necessary to continue these investigations in order to obtain that solid, broad basis of facts on which we may safely found a theory leading

* *Vide* Bechstein, "Organic Chemistry," 3rd edition, Vol. IV., p. 1630.

to the adoption of certain modifications in the feeding of ostriches. The feather of the lucerne-fed bird is certainly in general appearance more beautiful, but it is somewhat wanting in strength. It is most probable that this is due either to a deficiency of Silica in the inorganic constituents of the skeleton of the feather or to a predominance of sulphur in the keratine of the feather, or to both. That the general appearance of the feather is much influenced by the feeding of the ostrich with so rich a food as lucerne is unquestionable. But for the present the ostrich farmers do not know how the lucerne feeding is to be modified to grow a feather which is perfect in appearance and at the same time of stronger texture.

The study of the feeding of ostriches is of great practical importance, and something should be done to place the principles of ostrich farming, including ostrich feeding, on a sound scientific basis.

We have veterinary surgeons for the stock farmer, scab inspectors for the sheep farmer and a viticultural expert for wine farmers. Could not a small tax be levied on the export of ostrich feathers to meet the expenses of maintaining an experimental station for ostrich farming, at which all questions bearing on the life of the ostrich may be scientifically and practically investigated? It is to be hoped that this matter will be brought by the ostrich farmers to the attention of our energetic Minister of Agriculture, who has already done so much to raise and promote agriculture in all its branches in the Transvaal to a higher standard. It would be a new field of agricultural research, and the merit of having first worked in this new field of research belongs to my late friend Mr. D. S. Stevenson.

ARSENICAL POISONING BY LACTEAL TRANSMISSION.—Some months ago, Mr. J. Muller, B.A., F.C.S., Senior Government Analyst at Grahamstown, communicated to the Cape Chemical Society details of an interesting case of poisoning through the medium of mother's milk that had come before him. Several members of a Kaffir family exhibited serious symptoms of poisoning consequent upon arsenic having been placed in the coffee pot. One of these, immediately after partaking of the coffee, suckled her infant, who shortly after showed indications of arsenic poisoning and died, the other members of the family subsequently recovering. At a meeting of the Eastern Province Branch of the British Medical Association held at Grahamstown on the 9th December, Mr. Muller read an account of experiments that he had since performed in the above connection. Arsenically-poisoned beef was fed to a robust cat which had been separated from her four healthy kittens for over three hours. The latter were then allowed access to the mother, and half an hour after suckling symptoms of poisoning set in, terminating fatally in all four kittens. The adult cat recovered. Examination of the internal organs of the child as well as of the kittens showed evidences of irritant poisoning, and in the latter, as well as in the former, upon analysis, the presence of arsenic was demonstrated.

THE INSIZWA COPPER-NICKEL DEPOSITS.

By John George Rose, F.C.S.

The occurrence of copper in the Insizwa Mountain, near the village of Mount Ayliff, Griqualand East, was known some twenty years ago. Many half-hearted and wholly inefficient attempts were made to prove the extent and value of the deposit, but no work worthy the name was done until it was discovered, some five or six years ago, that nickel occurred along with the copper. In spite of the fact that this was really (in view of the Mond patents) an asset of doubtful value, the discovery of this metal seemed to give new life to prospecting operations in these regions and, for the first time since the discovery of copper there, a well-directed attempt to follow the lodes was begun. A friend of the author's brought him some hand specimens about June, 1908, and while assaying these for precious metals it was found that platinum was present in appreciable quantity. The author was at that time busy investigating a few problems connected with platinum, so his interest was keenly aroused and as the result of a confidential report on the subject to his Minister he was instructed to visit the mines and report fully upon them to the Government. The journey from Cape Town to Insizwa is long and tedious. The route followed was via D'Urban, thence through Alexandra Junction and Esperanza Junction to Sheartstown (Ixopo), where the railway was left behind and post carts, private carts and horses were requisitioned to complete the journey, via Umzimkulu, Kokstad, and Mount Ayliff, to the Insizwa Company's workings. These are situated, amid the most charming scenery, on the southern slope of the Insizwa Mountain, where the Waterfall Gorge affords facilities for driving adits along the deposits of ore. These occur along the line of contact of dolerite and shales, some 4,000 feet above the sea level, the metals being present as sulphides.

The contact dips north into the mountain at an angle of about 30°. Its outcrop is fairly well defined, and it has been traced from Ndakeni on the west, through Nolangeni, to the Ingeli Mountain on the Natal Border 30 miles east. Whereever it has been opened it has been found to carry copper and nickel, the mineralisation always occurring in the dolerite and not in the shale. Travelling in these parts during the rainy season is a matter of considerable difficulty, so that the author was not able personally to trace the contact as far as Ingeli as time was pressing. Most of his time was spent on the Insizwa Company's property, where a great deal of useful work had been done. This Company took over the rights of the old South Namaqua Company, whose unproductive and ill-advised workings are still to be seen. Originally along the contact between dolerite and shales the Insizwa Company has laid bare some rich bodies of Pyrrhotite ($Fe_nS_n+_1$), and Pentlandite (FeNiS), which ought to pay handsomely for their working—given railway facilities to the coast. The deposits therefore closely resemble the famous Sudbury

Nickel fields which to-day are among the world's largest nickel producers. At the time of the author's visit the Insizwa Company had driven their adit 175 feet west on the contact. Along its entire length the floor and south wall were in solid ore, the roof and north wall being in mineralised dolerites. A winze had also been put down, following the dip, for 150 feet, ore and mineralised dolerites being laid bare all the way. About 200 feet above these workings another drive was being put in following a decomposed dyke which occurs in the dolerites. This had reached a length of 60 feet and appeared fairly well mineralised, though by no means as rich as that first described.

Analysis of specimens brought by the author yielded the following results:—

Highest Copper content ...	19.3%
Lowest ,, ,, ...	1.2%
Average of 14 analyses	4.1%
Highest Nickel content ...	7.3%
Lowest ,, ,, ...	0.6%
Average of 14 analyses	3.8%
Highest Platinum content...	4oz. 19 dwts. per ton of 2,000 lbs.
Lowest ,, ,, ...	12 grains ,, ,, ,,
Average of 14 assays	2 dwts. 15 grains ,, ,,

Cobalt, silver, gold, and osmiridium occur in traces.

Two trial shipments of some five tons each sent to England soon after the author's visit were analysed by Messrs. Johnson, Matthey and Co., with the following results:—

	1	2
Copper	3.40%	3.50%
Nickel and Cobalt	4.90%	5.25%
Gold	6 grains per ton	6 grains per ton
Platinum	2 dwts. 12 grains per ton	12 grains ,,
Silver	10 dwts. ,,	12 dwts. ,,

About three miles east of the Insizwa Company's workings Messrs. Stack and Gilsen had sunk shafts to meet the contact. The author had not the opportunity of inspecting these workings, but was informed that ore similar to that exposed at the Waterfall Gorge had been struck, but very little work on the actual ore deposit seemed to have been done. At the eastern extremity of the Insizwa Mountain the Alec Payne syndicate was working. The contact had been laid bare and ore struck, but not enough work had been done to yield information of any value. The same remarks apply to the workings at Ndakeni at the western edge of the Insizwa range. These two points are some 13 miles apart, and between them the contact between dolerite and shales is easily traced all the way. Ore has been found at many places along this line, but no work worthy the name has been done except at the four places mentioned.

The future of these deposits will therefore be followed with interest, for, although many difficult problems will have to be faced, there seems no reason to consider the difficulties insuperable.

Chief among the problems is the question of transport. The author is very strongly of opinion that the best line of development will be through the port of St. John's, distant barely 100 miles. This magnificent harbour is still in its natural state, no attempts having been made to maintain a channel through the sand bar at its mouth. It could be made one of the finest harbours in the southern hemisphere, and there seems no reason to doubt that a comparatively small expenditure per annum would keep the channel open to a depth sufficient for present purposes all the year round. After a good freshet the channel is scoured out to a depth of 40 feet, and close on a year elapses before it shoals again to the usual 10 or 11 feet.

Rail to D'Urban is the only other course, a distance of over 300 miles, the line traversing very hilly country indeed. The St. John's line of 100 miles, running as it does parallel to the great rivers, can be built—and run—at far less cost per mile.

The problems connected with the separation of copper from nickel have been solved both chemically and electrically, and, though by no mean simple, the methods are capable of commercial application, the former method being that most in use. Invented and perfected by Dr. Mond, it has revolutionised the nickel industry and brought into use ores which previously it had not paid to work. All that is needed now is capital and brains, given which there can be little doubt that the prospects of the Mount Ayliff district are bright.

STELLAR EVOLUTION. — A paper by Sir Norman Lockyer, entitled "Sequence of chemical forms in stellar spectra," was read at the meeting of the Royal Society held on the 24th November last. By the use of a calcite-quartz optical train the author obtained a series of photographs of the ultra-violet portions of stellar spectra, which enabled him to check his previous classification of stars on the basis of temperature conditions, and allowed of very much finer detail in the results obtained, as well as greater certainty with regard to the "heat-levels" at which the various chemical forms of the elements predominate. In the hottest stars hydrogen, proto-hydrogen, silicium, carbon, nitrogen, oxygen, sulphur, and the cleveite gases predominate, and the lines of proto-chromium are more developed in the spectrum of ϵ Ursae Majoris than in the case of any other star hitherto examined. The lecture was illustrated by a number of diagrams and photographs showing the range of chemical forms which succeed each other in stars of rising temperature. The stars of the Alnitamian group in the Kensington classification have been divided into four species, and the relation of each of these to groups immediately above and below on the stellar temperature curve was diagramatically illustrated.

BUSHMAN ROCK-PICTURES AT D'SJATE.

By Henry Alexander Spencer, M.R.C.S., L.R.C.P.

In August, 1910, I found myself at Mr. Massey's Store in the extreme north-eastern corner of the Middelburg district, on a vaccination tour. This store is in the sub-district of Pokwani, perhaps six miles from the boundary of the Lydenberg district on the east, and 12 from the Zoutspansberg district due north. Learning some interesting details of two years spent by my host, close to a place called D'sjate, opening up an old copper mine, and of some Bushmen's rock-pictures of which he heard from one of his natives and visited, I determined to visit the spot myself and examine both of these objects of interest. The store at which I was lay some 65 miles away from the spot, the road to which ran along a valley, many miles long, at the foot of the magnificent, rugged range of mountains known as the Lulus. This valley was, as far as one could see, everywhere bushed with thorn trees, which appeared to be all of one height, and in the winter, devoid of foliage, gave a distinctly sombre look to the view. We passed Hackney, the residence of Mr. Hanse Winter, and the site of another store, past the scene of Secocoeni's last stand in the war of 1881, on Moudimo-Ua, and at sun-down on the second day reached another store about three miles from our objective. At D'sjate lives Rev. John Winter, who has lived there for nearly forty years; yet, although he understands and speaks Basuto like a native, until Mr. Massey told him of these rock-pictures, he had never heard of them, though they are to be found on the hillside no more than three miles beyond his house. Here, on the hillside of the Lulus, and about 150 feet from the floor of the valley, will be found an outcrop of rock from which the mountain range slightly recedes on either side, giving an extensive view for many miles up and down the valley. The rocky shelter, upon which the pictures are, is thus at the base of a projecting foot of the mountain and had perhaps a stragetic value to the occupants from the extent of valley visible right and left and beneath. The shelter is roofed and backed by this huge outcrop sloping backwards, partly the result of the splitting off of very large fragments, partly of weathering. At the foot of this sloping rock exists a sort of earth-strewn platform, formed by the stratum of rock, beneath the sloping face, projecting almost horizontally. There is nothing in the shape of a cave or aperture, merely a sort of rocky "lean to." On the face of this sloping rock are pictures in red pigment of Bushmen about four inches in height with bow and arrows, of an elephant, several hartebeeste, and a lion. There are a few Bushman women, also in red, recognisable by their breasts, in a standing attitude with uplifted arms. The men are mostly running, some shooting with a bow, but some are standing with arms outstretched in front of them, maybe pointing at the animals whose pictures are near by. At one extremity of the rock face, I should imagine facing eastward, are several black figures twice the

size of the Bushmen, if not larger still. These, which I imagine to represent Kaffirs, are apparently unarmed and running away from the red Bushmen. The figures of both men and beasts mostly face towards the left as one looks at them; they cover a surface of rock some eight feet by five, beginning about five feet from the level of the platform and extending to nearly twice the height of one Bushman. To draw most of them the Bushman must have stood upon something—either another Bushman or an object, *e.g.*, a trunk of a tree leaning against the protruding rock. The pictures are crude, giving the impression that they were the work of a novice, and with very little of the detail sometimes seen, *e.g.*, a quiverful of arrows, but here and there the swell of muscles is accurately depicted, and in one woman the characteristic shape of the breast is striking. They are scattered over the face of the rock without order or sequence, sometimes overlapping, here and there unfinished, and give the impression of having been added to at various times by different people. The sex of the figures is unquestionable. In the case of the hartebeeste, the accurately depicted shape of the horns and head determines the genus at once, but the elephant and lion are indistinct and appear to be unfinished; the former is in red, the latter in black pigment. These pictures, which at best are not very distinct, have in places been covered with a thin deposit of semi-transparent whitish substance which has run down the face of the rock from above. They seem to be very little known, even amongst the numbers of natives in the neighbourhood; but an old native woman, who knew them, was also acquainted with others of the kind in the same valley and about 25 miles away. She volunteered to guide anyone there who wished to see them, and pointed out the mountain slope they were on. At Hackney, which we had passed on our way about eight miles back, there are other Bushman pictures which I had not time to visit; they are described as "not so good" as those at D'sjate, and the rock upon which they are having fallen, they are difficult to see.

The valley in which the drawings I have described are to be seen is securely shut in by high mountains with few exits down other valleys similarly shut in, so that it strikes the visitor as secluded and likely to be a safe retreat; the seclusion is evidenced by the abundance of small game to be seen there at present, whilst a certain amount of larger game still exists there, *e.g.*, Koodoos, Wildebeeste, and Leopards.

TRANSACTIONS OF SOCIETIES.

South African Association of Engineers.—Saturday, November 5th: J. A. Vaughan, Member of Council, in the chair.—" The 'Mederer' Chilling Chamber": H. W. **Miller.** A description of a brick-work chamber designed for the preservation of perishable foodstuffs and the cooling of liquids. The bricks are perforated and especially shaped to permit the free passage of air while absolutely excluding all light. The building has a series of concentric walls, the outer annular space being kept constantly cool by means of water sprays.—" An economic aspect of mine labour as employed on the Witwatersrand Mines": P. **Snowden.** Suggestions for the systematic supply of more nourishing and properly prepared food to natives at work on the Mines.

South African Institute of Engineers.—Saturday, November 12th: J. A. Vaughan, President, in the chair.—" Notes on Mine head-gears": G. **Morris.** An illustrated discussion of various features connected with Mine head-gears which contribute to render such structures most highly serviceable. The author dealt in detail with the materials, strength, size and form of head-gears.

Geological Society of South Africa.—Monday, November 21st: Dr. E. T. Mellor, Vice-President, in the chair.—" The geology of a portion of the Grootfontein District of German South-West Africa": Dr. P. A. **Wagner.** An account of a preliminary reconnaissance of the District, embodying brief information with regard to its physical features, but dealing chiefly with the petrography of the area, the stratigraphical position of the rocks of various series described, and the correlation of the Otavi system with the geological formations of British South Africa.—" The correlation of the Kheis series": Prof. E. H. L. **Schwarz.**

ADDRESSES WANTED

The Assistant General Secretary (P.O. Box 1497, Cape Town) would be glad to receive the correct addresses of the following members, whose last known addresses are given below:—

Bell, W. Reid, M.I.C.E., F.R.Met.Soc., M.I.E.S., P.O. Box 2263, Johannesburg.
Boulton, H. C., c/o Messrs. Pauling & Co., Ltd., Broken Hill, Rhodesia.
Champion, Ivor Edward, P.O. Roberts Heights, Pretoria.
Dickie, Andrew, 475, Currie Road, Durban, Natal.
Mirrlees, W. J., 9, London Chambers, Durban.
Nichol, Thomas Thompson, P.O. Box 34, Springs, Transvaal.
Nicholas, W. H., Durban High School, Durban, Natal.
Pakes, Dr. A. E. H., P.O. Box 5, Belfast, Transvaal.
Petersen, H. T., P.O. Box 5, Cleveland, Transvaal.
Preston, James, 89, Arnold Road, Observatory, near Cape Town.
Southwell, Miss Jessie, 270, Visagie St., Pretoria.

NOTES ON HALLEY'S COMET, 1910.

By H. E. Wood, M.Sc., F.R.Met.S.

A long series of photographs of Halley's Comet was obtained with the Frankin-Adams Star Camera at the Transvaal Observatory, during the months of April, May and June, 1910.* They are reproduced in *Transvaal Observatory Circular* No. 4, and a brief description of them is given there.

It is here intended to refer to a few points of general interest which have arisen during the visit of the comet. As a wonderful spectacle in the heavens, Halley's Comet much exceeded all expectations; at least to those who were situated in favourable latitudes as we were in South Africa.

On the morning of May 17th, the actual and unbroken length of the comet's tail was found to be as much as 107 deg. On the 19th of May the head of the comet was not visible, but the end of its tail was 150 deg. from the place of the head. There do not appear to be any records of previous comets having tails of such angular dimensions. The only comets having tails approaching this size were those of 1618 and 1861 (ii), but the length of the tail of Halley's Comet far exceeded these.

The head of the comet was very brilliant, but its brilliancy appears to have been exaggerated in some quarters. It was not as bright as the head of Comet 1910 a, as this could be seen quite easily in full daylight, whereas Halley's Comet was never seen in the daytime. It was probably just about as bright as Saturn but not as bright as Venus. Although the tail of Halley's Comet did not present such irregular features as did the tail of Morehouse's Comet of 1908, yet there are many evidences of intense activity. The photograph taken on April 21st shows the most irregular tail of the Transvaal Observatory series of photographs. The appearances shown on the photograph suggest changes of an explosive character occurring near the head of the comet, followed by the propulsion down the tail of huge volumes of luminous matter. It has been shown by the examination of such irregularities, which appear on photographs taken on consecutive nights that there is a great increase of velocity as the matter recedes from the head. Near the head the velocity of propulsion is of the order of five kilometres per second, increasing to 90 kilometres per second near the end of the tail.†

Two photographs each of 31 minutes' exposure were obtained at the Transvaal Observatory on the morning of May 9th. The interval between the two photographs was only five minutes. A

*Eighteen of these—direct contact copies on bromide paper, from the original negatives—were exhibited when this paper was read at the Cape Town Session of this Association, and are filed with the Association's records.

† Lick Observatory photographs.

careful examination shows that even in this short interval there were certain changes in the tail. A well-defined streamer on the south side of the main tail apparently moved slightly, but quite perceptibly, away from the latter. This might either mean that the streamer was actually separating from the main body of the tail, or that the tail was rotating. Other photographs strengthen the impression that the tail had a rotary motion, and that the actual paths of particles along the tail were spiral curves. A continuous series of photographs taken at short intervals would probably throw much light upon the nature of the rapid changes which take place in a comet's tail.

The present and widely-accepted theory as to the origin of the tail of a comet is that it is formed of particles which have been projected from the nucleus with equal velocity in all directions. The particles which have been ejected from that hemisphere of the nucleus facing the sun are driven back by large repulsive forces emanating from the sun, and form paraboloidal envelopes having the appearance of a "sheath" over the nucleus. The particles expelled from the nucleus on the side away from the sun take no part in the formation of these envelopes. The "sheaths" are very well-marked on many of the photographs of Halley's Comet. They are rarely symmetrical but generally brighter and longer on the south side. On some occasions the central line or axis of the tail was darker than other parts, suggesting that the tail was hollow and formed mainly by the continuations of the sheath around the head. On other occasions the axis of the tail was relatively bright as though the tail were mainly composed of particles projected from the nucleus on the side away from the sun.

The most debateable questions in connection with the tail of Halley's Comet have arisen in connection with the predicted passage of the earth through it. This was to have occurred on the 18th—19th May, 1910, and naturally all preparations were made to observe a phenomenon of so rare a nature. What was actually observed was that the main tail of the comet remained almost stationary in the Eastern sky until May 21st, after which date the tail presumably diffused away. On the evening of May 20th, the nucleus, with a short tail, was seen in its expected position in the Western sky, but absolutely no connection could be traced between it and the great shaft of light seen the following morning in the Eastern sky. On the 18th and 19th of May, certain optical meteorological phenomena (*e.g.*, the appearance of Bishop's rings about the sun and moon), were so widely observed as to render a connection between their formation and the near vicinity of the comet's tail not improbable.

The full explanation of these various occurrences has yet to be given. In regard to the meteorological phenomena observed, it is very likely that some of the numerous streamers lying on the south side of the comet's tail crossed the path of the Earth; but it was quite certain that the main body of the tail lay to the North of the Ecliptic and could not have encountered the Earth. The greater difficulty is to explain the persistence in the Eastern sky

of the great main tail. The Director of the Transvaal Observatory has made the suggestion that at the near approach of the comet to the earth a rupture occurred, the greater portion of the tail remaining North of the Ecliptic whilst the nucleus, with a shortened tail, passed on to the South. This hypothesis explains the facts, but itself requires much explanation. The other theory suggested, viz., that the tail lagged very much behind the line joining the head of the comet and the sun does not appear to be in accordance with observed facts.

In connection with the rupture theory the great difficulty is to account for the enormous forces which would be necessary to bring to a stop particles moving with a velocity relative to the earth of about forty miles a second. The theory of light pressure hardly accounts for this; our knowledge of the electrical properties of the upper limits of the atmosphere is too meagre; the key to the mystery may lie within the comet itself; at all events the visit of Halley's Comet in 1910 seems to have left behind it more problems than before.

PORT SHEPSTONE MARBLE.—The latest issue of the *Quarterly Journal of the Geological Society* contains a paper by Dr. F. H. Hatch and Mr. R. H. Rastall on dedolomitization in the marble of Port Shepstone, Natal. The marble is well-known in Natal, and is of a beautiful white appearance, and coarsely crystalline in texture. Chemical analyses have shown it to be a dolomite, containing 34 to 38 per cent. of Magnesium carbonate. Whether this dolomite was originally deposited as such during the Swaziland period, or resulted from the alteration of a limestone is not clear. Intrusive granite of a pre-Devonian age completely surrounds the dolomite, which is also traversed by broad dykes. The authors, when visiting the marble quarries, were struck by the appearance of a block of granite included in the dolomite and surrounded by concentric dark brown, pale brown, and green bands or zones. This interesting occurrence led to a petrographical investigation. The granite block is either a soda-granite or a soda-aplite, and is surrounded in the first place by a dark coloured mica-olivine band, succeeded by a light mica-forsterite zone, and that again by an aggregation of white carbonate and greenish-yellow serpentine. Other inclusions were also noticed in the dolomite, and of these a felspar-scapolite-diopside rock and a spinel-forsterite rock are described in detail. The authors express the view that the included blocks of rock were deposited in the dolomite at the time of its formation, and that dedolomitization of the original rock occurred where silica from extraneous sources was available, silicates being formed in such cases. The included block of granite is unique amongst South African rocks, differing wholly from the grey granite of the circumjacent district. The dolomite and its included granite, the authors hold, were subjected at the time of marmorization to very high temperature and great pressure in the presence of water vapour.

IRRIGATION FINANCIAL PROBLEMS IN THE BREEDE VALLEY.

By Thomas Earle Scaife, M.I.C.E.

INTRODUCTORY.

Financial problems connected with soils and their cultivation are intricate and complicated. In few other spheres of usefulness do so many unknown quantities appear, or such diverse problems present themselves as are found by men engaged daily in overcoming natural forces. Text books may serve as a guide; but only constant, practical application will teach how the sources of power in Nature can best be utilised for the advantage of mankind. The art of irrigation being closely akin to the cultivation of the soil, all those connected with that branch of engineering find their daily occupation in close touch with Nature, with its ever-varying moods and conditions. Soils, climates, water, all are elusive elements ready to baffle the untrained novice who will step into their domain.

FINANCIAL INFLUENCE IN IRRIGATION MATTERS.

No Civil Engineer can be long associated with the problems connected with irrigation in South Africa before he finds that the predominating factor in all schemes is the financial influence. This financial influence permeates every project from its inception, and is the main feature tending to the production of any successful scheme of irrigation in this country. In other countries subject to drought, schemes are undertaken to mitigate the effects of famine caused by the fluctuation of the rainfall, in order to feed a starving population. Such problems are non-existent in South Africa to-day. With us the first element is, will the land, when irrigated, pay the water rate to be imposed for a number of years to redeem the loan, or prove remunerative upon the capital invested in the project?

SUITABILITY OF SOILS FOR IRRIGATION.

The problem as to the suitability of certain areas desired to be brought under cultivation is one beset with many difficult pitfalls prepared for the unwary landowner who will embark upon irrigation works without previously having obtained expert advice upon the subject. It can be stated that one-half of the sum now being expended upon minor irrigation schemes by farmers, and others, without first obtaining good advice, is lost through many causes.

These losses are often incurred by faulty workmanship, in other cases by the unsuitability of the soil for irrigation farming and by the lands having too steep a slope. This expert advice

is obtainable from Irrigation Engineers, and the farmer should have little hesitation in embarking upon a scheme recommended by engineers of undoubted qualifications and experience in methods applicable to this sub-continent.

RESULTS OF IRRIGATIONAL DEVELOPMENT IN BREEDE VALLEY.

During the last decade irrigational development has been steadily proceeding in the Breede Valley from a small beginning, whereas to-day it is one of the principal irrigating centres in the Union. To watch this development and its influences upon the farming community is of much interest. The enhanced value of the ground with the attendant high prices paid for ostrich farms have induced many landowners to dispose of their properties and purchase farms where land is cheaper in the North. However unwise it may appear for a man to sell his farm and leave the district, his home and his friends, this roving disposition is a valuable asset to the community, for the farmer is already an irrigationist, even though in a small way. He therefore will continue and use his irrigational experience in the arid districts and spread his knowledge amongst a stock-farming community, where a few morgen of cultivated land is a valuable adjunct to stock-raising. Whereas the purchaser, having paid a large sum for the property, and having bought the farm with a view to its further development and its large possibilities, again carries the advancement a step further, and there is a gradual growth and progress of improvement.

FINANCE FOR DEVELOPMENT OF IRRIGATION FARMING.

In the early stages, when the water has been delivered to the irrigable lands, the financial problem causes anxiety to the owner, who is willing to develop his farm and who has not the necessary capital to tide over the first few years. To overcome this financial difficulty, some owners dispose of one half or a portion of the irrigable land. This, in many cases, is indeed a hardship, where a farmer has several sons, who, in a few years, must be settled upon the farm. There is at the present moment a most urgent necessity for funds at a low rate of interest to be advanced for development of irrigation farming in its initial stages. These advances should be made in an unostentatious and ready manner to deserving applicants, and so retain men who are irrigationists upon that class of farming to which they have become accustomed, and not drive those who are skilled in water leading, and its attendant mode of cultivation, to pastoral pursuits.

COMBINATION BY LANDOWNERS.

The development in the Breede Valley has accentuated the indispensability of combined effort by the landowners. Most of the minor projects, where individual effort can overcome the financial problem incident to the construction of a scheme have already been completed.

It is now rare for a project of any size to be discovered which can be undertaken by one individual single-handed. Vested rights have been established upon the streams. These rights can usually be acquired by purchase when an Irrigation Board has been formed and the many interests coalesce for the general advancement. Unity gives strength. Funds for the construction of the works are more readily obtained. Legal advice is more accessible to the Board through the Secretary, who is usually an Attorney. The Engineer appointed to supervise the work will advise upon the engineering details. When the scheme is completed and in operation the maintenance is more efficient and the canals can be kept in a good state of repair by a permanent maintenance gang, who devote the whole of their time cleaning and improving the methods of distribution.

IRRIGATION BOARDS.

From a small beginning in 1899, eight Irrigation Boards are now in operation in and adjoining the Breede Valley, while six others are in various rudimentary stages. These Irrigation Boards find no difficulty in raising the necessary funds for the furtherance of their projects. The Banks are willing to make advances upon favourable terms to bodies showing such health, energy and vigour. So far no financial aid has been made by these bodies towards the development of the irrigable areas owned by the shareholders, for fencing, levelling, or drainage of the lands. It is now a question whether these Boards should not be legally empowered to make such advances, at a low rate of interest, and so hasten the cultivation of the lands commanded by the canals, and at the same time give the shareholders an opportunity of tiding over their early financial embarrassments incidental to the cultivation of new lands.

ECONOMICAL CONSTRUCTION OF IRRIGATION PROJECTS.

Economical construction has a predominating influence upon every project. It is only by close attention to detail, especially in the removal of earthwork in the excavation of canals, and forming of reservoir embankments that the cost of any scheme can be kept down. To those uninitiated in the rudiments of excavation the removal of the excavated material appears a simple matter. It is only when the cost per unit is ascertained that it is possible to say if the excavation is proceeding in a satisfactory manner. When a small reservoir is being made, and only a few men are engaged, skilled supervision and refined organisation are not so essential; but when a work of some magnitude is under construction, large sums can be, and are daily misspent, because the man in charge is not capable of arranging the plant and workmen to the best advantage.

PERSONAL ELEMENT IN CONSTRUCTION OF WORKS.

It is this personal element which is so elusive and difficult to gauge when preparing an estimate of the cost of any scheme. Should it be known in advance how a work will be constructed, the

problem is somewhat easier and the prices can be ararnged to coincide with the personal element and class of supervision likely to enter into the work. It is known that in many cases where the material excavated should only have cost sixpence per cubic yard to remove, by bad management and shortage of requisite plant and tools, from 50 to 100 per cent. has been added to the cost of the project. This item alone will often turn what otherwise would be a payable work into a failure by over capitalisation. This feature is one which is ever-present where works are constructed by an Irrigation Board. The members of these Boards are unable to appreciate anything but manual labour. A fussy overseer will impress the members of the Board greatly, while a man of few words, who calmly supervises his work and the labour is seldom understood, nor are his organising abilities perceived by the average shareholder.

The Boards are inclined to engage men to be placed in charge of works who have failed at other occupations in life, and are content to work at a low rate of pay. Such supervision can only result in loss. An urgent necessity at this moment is a band of experienced, good men in the country, who can organise the building of canals and reservoirs with economy. This class of men is to be found in every country where irrigation is proceeding. There is no doubt this class of overseer will become available as the development proceeds and the demand increases for men who are good foremen, men who are not afraid of hard work or an isolated life upon the veld, receiving adequate wages to compensate for the discomforts and loneliness.

FOOTHILL VERSUS VALLEY IRRIGATION.

There is a strong tendency in the farming community to encroach upon the lands near the headwaters of all streams, and place under cultivation ground near the source of the water supply. The upper proprietor is gradually, upon most rivers, steadily developing and extending his farming operations higher up the mountain slope to obtain a better supply of water at the expense of those farms situated upon the plains. This gradual advance into the mountainous regions is being attended with disastrous results to the community. For the removal of the natural growth upon the sloping lands high up the catchment areas is causing the rainfall to flow off the land with greater rapidity year by year, resulting in the serious erosion of the country, so patent to all. Usually the land situated amongst the foothills is not of such fertility as to warrant its cultivation at the expense of the more fertile areas at a lower level. The slope is too steep for efficient irrigation, and the virgin growth, had it been allowed to remain undisturbed, would have held up the rainfall and caused a slower and longer run off along the drainage lines. The financial problem presented here is to allow the mountain slopes and the foothills to remain in a natural state and convey the water issuing on the mountain range to the suitable lands in the bed of the drainage system. Now that owners are seeing the advantage of using water upon the best lands there is a tendency for schemes to be devised

whereby the water can be conveyed from the mountain to the plain, and at the same time convey the water, instead of produce, to the lines of communication which are more accessible in the valley basin. A scheme of this description was completed in the Nuy Valley over two years ago. The Chairman of the Nuy Irrigation Board says as follows, viz. :—

> At his own valley of the Nuy the new irrigation scheme has doubled the general productiveness in two years. The farmers, instead of being limited to small patches of ground, had now unlimited scope. Not only the better soil, but poorer ground as well was under cultivation and large dams were being constructed, so that when the Nuy was in flood, very little water would run to waste.

This Board has recently purchased properties situated high up upon the catchment area of the Nuy River, and are enforcing regulations for the control of water gravitating to their farms. A man stationed upon the catchment has strict instructions not to allow any veld burning, or the cutting of bush, the idea being to allow the property to become covered with a natural growth to conserve the water supply. Highly successful as the irrigation project in the Nuy Valley has become in the short period of two years, not a tithe of the possibilities there have yet been developed.

In a valley adjoining the Nuy are the Nonna River Irrigation Works, where the water has been tapped upon the mountain slope and conveyed by means of a 9-in. diam. steel pipe to the irrigable lands situated beyond the toe of the mountain range. This project has been in operation over two years, and the results are highly satisfactory. Other schemes of this description are under construction in the Breede Valley, on the Doorn and the Noree Rivers, where the waters are to be conveyed either by canals or pipes from the mountains to the more fertile areas in the valley. Such schemes are highly profitable to the farms upon economic grounds. The advantages are :—

(1) By keeping unimpaired the catchment area, the water supply is conserved; therefore tending to avoid a too rapid run-off of the rainfall with consequent slooting.

(2) Any surplus flood water can be more economically stored near the cultivated lands than upon the steeper slopes of the catchment.

(3) The flatter lands of the valley are able to retain the moisture; therefore the water is used to better advantage.

(4) The lands of the valley are usually more fertile with a greater depth of soil than the lands situated at higher levels in the basin. Near the river banks the lands usually flatten out and there are found the best Karroo soils.

(5) The means of communication, railways and roads are more accessible in the valley—consequently the cost of transport for produce is less, and the handling becomes more speedy.

(6) The farms are more accessible to the commercial man and better prices are obtained for produce, resulting in an enhanced value of the property and agricultural wealth.

Therefore it should be urged, where possible, the closing down of cultivation upon the slopes usually receiving a fair rainfall and allow the natural gorwth to predominate. The irrigation water should be conveyed, by efficient, inexpensive and speedy methods, without loss in transit to the best soils on the Karroo flats. Even

if the actual area under cultivation is not augmented, the transference of water from the foothills to the plains will usually result in larger profits being derived from each irrigable acre, by an increased output of produce and reduced expenditure of labour in the cultivation of the soils. The possibilities for carrying out projects of this description, financially feasible, along the two ranges of the Langeberg and the Zwartberg are enormous. At present most of the permanent streams upon these two ranges are fully utilised for irrigation purposes, but their usefulness can be immeasurably increased by development upon the lines initiated in the Nuy Valley and other places previously mentioned. A golden rule for irrigationists is: "Convey your water by gravitation to the railway, and not your produce."

Recent experiences have shown that a combined body of farmers is fully alive to advantages likely to accrue by development upon scientific lines, where the projects are financially sound. The continual intercourse between landowner and the Irrigation Engineer is bearing useful results, while the practical demonstration of actual facts as to the value of irrigable lands commanded by well-thought-out schemes, is bringing men into line who would, a few years ago, have exhibited strong opposition to large projects constructed with state aid.

The larger works now deemed necessary for the conveyance of water over long distances require large sums of money, as well as a considerable amount of patience to bring them to fruition. These works are usually costly and beyond the scope of individual effort, besides being impracticable for private enterprise.

ANNUAL WATER RATES.

Before any irrigation project can be accepted as feasible, the cost per morgen for supplying the water must be considered. Experience has shown that an annual water rate of one pound per morgen per annum is a payment which does not prove burdensome to the farmer. That sum is the highest water rate in force at present in the Breede Valley, including maintenance charges, which the landowners are generally willing at this stage to entertain. This water rate could be doubled with ease without the farmers finding the water too expensive upon the best soils.

However, as the landowners are unprepared to subcribe to schemes where the water rate is likely to cost £2 per morgen per annum, there is nothing to be done but allow the more costly projects to remain in abeyance until the demand increases for irrigable lands. This pertinent question of the annual water rate is one which is uppermost in each project. It is a question which must receive careful examination. An ideal form of payment would be a graduated tax upon the various classes of soils dominated by the project. But who is to decide which class of soil must pay a 20s., and which class a 10s. water rate. Naturally each owner would wish to pay the lowest sum. Therefore, all lands pay one uniform rate, so the ground can only be rated at a sum which meets the lowest classification of soils to be irrigated. In a scheme where all the land to be irrigated is under

one ownership a graduated rate based upon a soil classification would apply; but these conditions are not to be found in the Breede Valley. Nor is there any likelihood of any large scheme being constructed where all the irrigable lands come under one ownership.

CONCLUSION.

In conclusion, I have no hesitation in calling attention to the experience gained from the early efforts being made in the Breede Valley by Irrigation Boards consisting of the landowners. The last ten years have brought the subject beyond the experimental stage, proving it of such vast importance to this country. In a paper which must necessarily be short many of the points pertinent to irrigational enterprise by co-operation can only be referred to briefly.

The possibilities of landowners becoming associated for the promotion of irrigation works are enormous throughout this country. These possibilities are seen on every hand. In every valley, and upon every river contiguous to land suitable for the cultivation of crops by irrigation are areas and opportunities which should be made available for homestead settlement. These problems are only to be solved by sound engineering advice in conjunction with healthy financial aid given to the enterprising farmer for the development and cultivation of the rich tracts of land hitherto without water for irrigation purposes.

ZOOLOGICAL NOMENCLATURE.—In the Report of the International Commission on Zoological Nomenclature, mention is made of a widespread and deep-rooted desire on the part of zoologists to except certain commonly used zoological names from the *Law of Priority*. The Commission accordingly, as an experimental proposition, invites all zoologists to furnish the Secretary of the Commission with a list of 100 generic names which they may consider should be studied in connection with the preparation of an official list. All systematists are further invited to communicate a separate list of genuine names in their speciality. Zoologists and palaeontologists giving courses are invited to supply a list of the text books which they use, so that the generic names therein may be indexed. The Commission's intention is to submit the selected genera, after alphabetical arrangement, to group specialists for their opinions. The names will subsequently be tested, a provisional list published for general criticism, after which an official list will be issued, and a resolution taken to the effect that no official name is to be changed until the reasons for so doing have been submitted to the Commission and pronounced valid.

THE NEW UNION GOVERNMENT BUILDINGS, PRETORIA.

By William Lucas, F.R.G.S., F.R.V.I.A.

As an introduction to the setting of the new Union Government buildings, at Pretoria, one cannot do better than take his stand at one of the windows of a lofty building in the centre of the city and note the extensive crescent of sky line. Beginning with the gilded figure that crowns the dome of the Houses of Parliament, (which also house the Governor-General's staff and officialdom generally) the varied view terminates in a disused fort on a hill-summit. Overlooking much of the city proper, at this spring-tide intensely foliage-clad, the eye rests upon a stretch of gently undulating country, sparsely dotted with structures, beyond which several tops of mountain peaks are visible. To the left this relative plain terminates in a double-breasted eminence, which, from every view-point, constitutes the conspicuous feature in the city's landscape; and in return, its summit after little more than an easy half-hour's walk from the centre of the city, offers an extensive panorama in every direction of charming interest. Truly, as a writer has said, "it is an ideal Acropolis for a capital city"; and it is upon the southern slope of this height of Meintjes Kop that there is now arising the new buildings for the administration of the Union of South Africa.

To the vision of the seer, having some knowledge of sites which had appealed to the great artists of the past, and which moreover had gone so fully towards the making of classic master-pieces, it could only be too evident that there hovered over Meintjes Kop the spell of destiny; and that the southern slope, in so close proximity to the city, worthily ranked as ideal for an imposing pile. To such an one possessed of the subject, on reaching that summit, there would flash before him the primary points of vantage. If of Gothic tendency, the mind-diagram would project an irregular mass in harmony with the contour of the site, to be dominated by twin features grouping with the breasted heights. And if the field of competition had been open, and a Gothicist had proved successful, I think I may say without hesitation the product would have been a phase of architecture worthily rivalling Liverpool's vast cathedral now in progress. But to one of classic tendency, the boldly defined axial line extending from Onderstepoort and Doornpoort northwards over the saddle of the kop, and southwards through Groenkloef and the Fountains Valley, would so sway his mind-diagram, that whatever was planned the centre and aspect were immutably determined.

Co-operating with that main axial line were the transverse points bearing towards sunrise and sunset and respectively dying away into the horizon amid distant hills. But while fully conscious of the demand of the ideal, as a matter of practical reckoning there loomed a great depression, which had been (as it were deliberately) placed to mar the otherwise naturally fine site for a national structure.

To ignore the axial line would be unthinkable, so the difficulty of the depression must either be overcome, and rendered as non-existent; or retained and recognised as an appeal or challenge.

It is now a matter of history that the heroic course was decided upon, and the ominous feature boldly thrown into the centre of the scheme. Perhaps from an utilitarian point of view the treatment consequently involved, meant a course open to considerable criticism, for it necessarily also meant the conferring upon an essentially utilitarian structure an outstanding element of idealism. But possibly the expense so involved has not been greater than any worthy alternative method would have been. For if the "trouble" of the depression had been absolutely disposed of and a level rectangular plateau secured, there must have been, among other demands, the fuller breaking of a continuous frontage, the introduction otherwise of pronounced relieving features, and something of the pre-eminently assertive in regard to the skyline, and that would also eventually pull the whole together.

The opportunity certainly was unique, and coming at a period in the history of architecture when scientific planning is securing so ample attention and its genii so ready to hand, Mr. Herbert Baker, the accomplished architect entrusted with the scheme, was exceptionally fortunate; and combined with an able recognition of the possibilities of the site, the result will be South Africa's possession of a structure of a very high order, and one in fact that promises to rank worthily among the noblest buildings of the Empire—moreover it is a structure that will add considerable fuel to the imaginative faculties.

But in the absence of an open competition, with the resultant concentration of a number of able minds upon the subject, it is, of course, impossible to determine whether the design now being carried into effect would have attained the premier position. From what I know of the architect, I have confidence that he would be ready at its completion to state,as did his great namesake, the late Sir Benjamin Baker, at the opening of the Forth Bridge (and mentioned also to me by him personally, when visiting South Africa), "that he believed there were several who would have done equally as well as he had done, if only they had been favoured with the opportunity."

So packed with poetry, and having symbolism writ so large upon the scheme, I may be pardoned for some allusions of a prefatory nature.

Most wisely has the main axial line been clearly maintained, and a vista rendered possible from the south of the monumental saddle of the Kop; while from the North, representatives of the State on arriving for the discharge of their high duties, may have a vista of the country which for the time being lies so fully at their feet.

And most suggestively in the immediate forefront of that view stretches an open-air amphitheatre, fit reminder that their tenure of office is dependent upon the people's freedom of will. But there is far more than ministerial reminder in that amphitheatre and its accessories; for the people themselves will meet there for great receptions, for the recognition of merit, for the conferring

of the freedom of the Union, and to exult in the deliverances of rhetoric and poetry and music. And as they so assemble, ranged in full view of the statue of royalty, will have not only forcible reminder that duty to the Sovereign and to the Empire are of supreme importance; but a keener sense of largeness in the abstract and of the larger issue of things South African will be aroused and deepened. Fittingly that symbol of constitutional government is centrally set on the frontage line at a point conspicuous from every direction. And though that royal statue be of heroic dimensions it will give a sense of scale, as well as tone, to the whole composition. That the dome-capped Ionic rostrum should be practically, though not absolutely, at the crossing of the axial lines, is eminently suggestive, for upon the sway of speech so much depends. And I also note that that rostrum is the axis from which all ministerial haunts (apart from the ministers' respective chambers), whether for purposes of conference, committee, study, recreation or refreshment, radiate.

To what extent, if any, the few poetic facts I have stated swayed the architect's mind I have no knowledge; nor do I know whether the double-breasted Kop (with the selection of which for the site of these buildings I have heard he had much to do), suggested to the mind the two great peoples from one common stock in this Southern land. Or, following that symbolism, that two practically identical blocks based upon the grace of the mind-diagram of the Greek ought to be planned, and moreover be united by the curve, which, indelibly stamped in the mind of the Roman, meant (and is still meaning) so much in the way of law and order for civilisation.

Yet there is one thing I *do* know regarding the architect and this master-piece, viz., that he has seen fit to keep in reserve that adaptation of South African architecture which he has made so peculiarly his own; recognising that in the magnificent commission entrusted to him there was an imperative call to go back towards the beginnings of the Empire, and base a design on architecture's deepest Imperial principles, the problem being the disposition of a mass of Executive and Administrative Offices (each well-lighted, ventilated and readily accessible), in a form that would possess a considerable element of monumentalism.

Towards the achievement of that disposition, from the main axial line, with an inner radius of 138 feet, has been struck a semi-circular block, 34 feet in depth, and screened on its southern sweep with a colonnade the height of the two upper stories. Beyond, on either side, extends a block with a frontage of 305 feet and a general breadth of 138 feet, while the horizontality of this hill-set structure of 915 feet is relieved at the internal junctures by towers. The curved section is essentially ministerial, and is approached on its northward side by a high level road that gives immediate access on to the first floor, upon which the bulk of the Ministers' Chambers is placed.

At the most northerly point is situated a 12-columned circular *porte-cochere* some 36 feet in diameter, from which, after passing over a low-level roadway, a great triple colonnaded vestibule is reached. This (entirely open northwards and southwards) is in

many respects the artistic climax and grand view-point, and some 45 feet above the tram-line on the Southern frontage, commands not only the full view of the axial features in amphitheatre, lawn and water-stretches, roadways, terraces and steps (and ultimately piazza and gardens rich with statuary and typical products), but beyond to the distant hills that stretch away from Groenkloof. And, particularly when flooded with the splendour of South Africa's high altitude spring-tide, the charm of the view from this point, 4,565 feet above sea level, will indeed be exceptional.

From this vestibule westwards extends the library, and eastward (covering an equivalent area), restaurant, Ministers' luncheon room and accessories.

The library, with its major dimension of 134 feet, and some 29 feet wide, and having a clear vertical space of 25 feet, with saucer domes rising above, is enriched with teak-cased piers, galleries with a series of curved balustradings of plaster finish, the varying perspectives seen on either end, especially towards the setting of the tempered sun, will, to my mind, make this room one of the most effective scenes in the entire structure.

The restaurant, while possessing much in common with the library, will, by reason of its covered ends and sets of double engaged teak columns, have its own distinctiveness; and the same applies to the Ministers' luncheon room, with its plain panel ceiling and fireplace cove.

On the ground floor are placed masses of offices, including a post office, entered directly from the lower road level on the north, and it would be unpardonable not to refer to the tea room on this floor, a crypt-like chamber which is columned, vaulted and wall-tiled on the lines of old Dutch work, with singular severity.

As there was not the necessity for the interior of this central portion above the ground floor to be broken up as elsewhere, and height was essential, there is a consequent breadth of treatment which means that its northern frontage holds the paramountcy in external design. For the sake of this, it is to be regretted that there is not more vantage ground to the north.

Terminating this semi-circular portion at either end, and thereby uniting it with the Eastern and Western blocks respectively, are conference, reading, committee and other rooms. Each of these possesses distinctive features, but it is impossible to fully individualise all.

The conference and reading rooms of circular form are each 50 feet in diameter and possess domed ceilings, whose crowns are 36 feet from the floor. In the former, with ionic-capped columns of red granite, dais, alcoves, gallery and glazed and grilled lights surmounting entablatured panelling with shields and ribbed relief carving, a considerable play of both plan and detailed treatment centres.

The committee rooms, each measuring 44 feet by 25 feet, occupy angles and are among the most satisfactory portions of the external design, and generally materially contribute breadth to the whole composition. Internally the effect of these rooms with segmental end, pendentive groining, and walls broken with

broad-fielded panelling and plasters, cartouches bearing the arms of the principal municipalities of the Union of South Africa, will have much that is commendable.

Reference has already been made to the uniting externally of the central and end blocks, but something more should be added as to the method of union. In addition to the rooms mentioned at these junctures, behind each of the extremities of the concave colonnade is an ante-chamber, and from these, clock-towers of stone, 30 feet square, rise some 90 feet above the general roof-line, giving a total height of 160 feet from the level of the public road which immediately skirts the southern frontage. And for the apex of each tower the contract provides a bronze figure, some 10 feet high, and whose head will be exactly on a level with the line of the summit of the Kop.

Now the visible portions of these towers, with their buttressed colonnading and domes of stone on concrete vaulting are satisfactory enough, but they suffer somewhat in idealism. A tower, to be entirely satisfying should rise visibly from the ground, at least an angle and two return sides; and, moreover, in a classical building its purpose on plan should be a well-expressed factor in the scheme. Had towers as designed in the upper outline, been so embodied (as I think they could readily have been), I believe further impressiveness would have been added to the architectural whole.

The end Blocks, 148 feet from the axial line respectively eastward and westward, are somewhat H-shaped, the lateral portions measuring 235 feet by 138 feet, with transverse ends 208 feet by 35 feet.

The secondary axial line slightly converges inwards towards the centre, and this diversion results in a general curvilinear effect to the set-out of the southern frontage and a wedge-like leading to the amphitheatre that will not be without a considerable measure of piquancy. Ranging in line with the ends on this side, are terraces 35 feet wide which elevate the ground floor 17 feet above a public roadway; which latter, in its turn, is practically the massive retaining wall of the plateau on which the whole structure appears to stand, though really based on the rock beneath. The dominant elements in each of these blocks consist of the pavilioned end bays, and the central court; the first relating particularly to elevation, and the second almost exclusively to plan.

Within these end bays are ensconced the chambers of the Ministers of State, each 31 feet by 24 feet in the clear, with a spacious columned alcove that projects into the pavilion. The shafts of single blocks of dark grey granite support massive baulks of teak that cross the ceilings with bold brackets resting on freestone corbels.

Two similarly purposed chambers (to complete the requisite number) are placed at the angle terminals of the central block, and, while without the accompaniment of pavilions, have compensation in being in direct touch with the amphitheatre.

Over these several Ministerial chambers are distributed teak, stinkwood and clear pine, left in a state that exhibits the different tempers of these woods, and with their constructive pins and dove-tailed keys, cannot fail to give an acceptable contrast to more finely finished work elsewhere.

The Central Court to each of the end blocks, placed axially in both directions, has an area of over 2,000 feet directly open to the sky. Loggias, intersected on north and south sides, with additional rows of columns, are around on each floor, and immediately associated is one of the main staircases, the whole being generally executed in a reddish freestone, with the face and mouldings finely chiselled.

Giving relief to the masses of red freestone, on the lower floor are double columns (single on face) of finely-wrought, but unpolished, red granite, supporting arches; while on the upper floors are triple columns (double on face), in one instance with arches and in the other with lintels; and in all cases without responsive piers at the internal angles. Sections of lofty balustrading are introduced in the plain walling. The ceilings are of concrete, the two latter exhibiting groined vaulting, and the upper red brick arching between cross beams. For the centre of each court a fountain has been provided.

Though intensely eclectic in feeling, these Central Courts, with their accompanying loggias, not only confer a sense of spaciousness well in harmony with the temper of the situation, but their whole treatment promises peculiar satisfaction.

The adjacent main staircases of double flights are a combination of vari-tinted stone, having columns and handrail in polished red granite, and relieved with iron standards, newels and balustrading; while on either side are passenger elevators.

Axially to these courts, on their southward frontage, are the principal entrances, with vestibules and porches which span in open formation the frontal terraces, and enable direct access from the public roadway level.

Similar, though subsidiary, vestibuled entrances also occur on the north; and, together with corridors 9 feet wide, give access to the various offices, which, by virtue of the addition of minor courts, are ensured a great amount of cross ventilation.

Such a plan, though fraught with numerous admirable points, necessarily means the considerable severance of some departments of State from others; and, in days prior to ease of telephonic communication, would have furnished just ground for substantial criticism from a purely utilitarian standpoint.

Into any analysis of the external representation of architecture there must enter a recognition of three factors, viz. :—Base, superstructure and covering. As to the base (which also presupposes foundation), it is self-evident that the more there is indicative of strength the more satisfying the composition of the whole structure. Blocks of great size prevail here, and, moreover, of granite, thousands of cubic feet being absorbed in importing strength, structurally and aesthetically, to the basal feature. Superstructure primarily implies accommodation of plan, and the consequent demands of entrance and fenestration. In this

instance, daily provision in office accommodation is necessary for some 1,000 persons, with extensive archive room. As to covering, the requirements are,—resistance to the elements, the greatest simplicity compatible with dignity, and recognition of climate.

As will have been realised from my previous remarks on plan, the structure is comprised in two practically rectangular blocks, connected with a semi-circular colonnaded block that encloses an open-air amphitheatre. By reason of the contour of the surface, and the disposal of the accommodation, the central portion appears one-storied on a lofty basement; while the flanking blocks exhibit three main floors and a basement.

Taking the public roadway as the baseline, the structure has a height of 61 feet to the eaves, and of a further 12 feet to the ridge. With the exception of the two towers already referred to, and a few chimneys, there is no break in the horizontality of either eaves or ridgeline throughout the entire length of elevation. The Ionic order prevails, but considerable liberty has been taken in regard to the entablature, particularly in the omission of the frieze.

The interest of the architectural treatment externally is mainly, in the eastern and western blocks. Being of administrative nature, the demands for fenestration have been heavy, yet amid the variation of window head (level, segmental, shouldered segmental and semi-circular), there is throughout reserve, and, almost without exception, single-wall openings prevail. Double-shafted windows, however, occur at the centre of the upper tiers, while some distinctive features are bestowed upon those of the rooms of the several Ministers.

As in matter of plan, so, elevationally, expression is given to the subsidiary axial lines of these respective blocks. Northward the long stretch of continuous surface is emphatically broken above the ground floor with recessed double-columned bays, 60 feet in width. Southward the feature is a main entrance porch, that (the reverse to the northern feature) gives a touch of lightness. Somehow, as Britishers, we are not naturally strong in the mastery of the entrance, compared with other European peoples, and more of the modern Greek assertiveness, for instance, might more generally be applied with advantage. However, with convex steps at the public roadway level, and the passing through the massive retaining wall, these multi-columned porches, with a concaving of the central portion of the entablature, and granite (black, grey and red) entering into shafting, steps, and paving, confer the emphasis of entrance in a striking manner. And reference should be made to a loggia'd frontispiece screening the window immediately over this porch, and bearing the Royal Arms, as being the only break in the long stretch of upper fenestration that lies between the end pavilions; except that a single window centrally on either side is pedimented and possesses a balconette.

In contrast to the repose, and consequent tranquillity, of the lateral portions of these blocks, the projecting extremeties possess exceptional boldness of treatment. Instead of wall-surface,

columns appear the height of the two upper stories, and certainly seem somewhat, at first glance, out of harmony with the intervening architecture. But it is soon realised that reliance is placed upon these extreme features to give buttressing to the entire design. Resting at either transverse end on double-storied masses of a keep-like nature, which have a touch, and only a touch, of the Later Renaissance, these groups of columns, 23 feet high and 2 feet 7½ inches in diameter, double-rowed at angles, and each forming a pavilion 35 feet wide to a chamber of a Minister of State, assert, with almost imperious audacity, a sternness to an expression of architecture in which otherwise there is much vivacity, and even some playfulness.

Piercing the lower masses are bold archways with vaulted passages that give access to the terraces, and beneath are staircases that lead to the tram road which skirts the base of the terraced public way.

Æsthetically, I think the supreme note of the base and superstructure is that of magnitude, in the sense not necessarily inherent by reason of bulk (though this is present in large degree), but contributed to by the cultured disposition of the various parts I have mentioned.

Then, several matters of detail have played their part towards this note, such as the battered face to the granite base, the method of the piercing of that base for the main entrance, the graduating of the wall-jointing; allied with the relative fewness of continuous horizontal members, the general curvature to sundry angular features, and by no means least, the sense of scale which the balconettes thrown out here and there unquestionably give.

The next influential note I would place is that of texture. Wisely, or unwisely, the designer determined to deal in broad masses favouring horizontality, rather than that verticality which the site seemed to suggest, and reducing projecting features to a minimum. All this line of action of course means that over such an immense surface area definite shadows will bear but a small proportion to the light. This being so, a far fuller demand is made in the direction of texture—the variation of surface-treatment—which will lend itself readily to the influences of the sky. The demand is a great one, particularly upon the north elevation, but I think from all points of view the various frontages will succeed in meeting the accepted canons of criticism as to this note. And its success will owe much, as texture ever does, to the nature of the various materials, the character of workmanship, and the method of their setting.

I have stated that granite enters into the composition, and this it does to the extent of 14,000 cubic feet. In blocks of heroic dimensions, grey granite forms the plinth, extending generally to the springing of the lower arches and including the arches of the respective pavilions. Balmoral freestone forms the superstructure, and from the top of the granite to the underside of the plinth of the terrace's balustrading, and to the set-off level under the ground floor window sills of pavilion ends the work

has a rough rock-face, so wrought as to give rusticated joints about 3 inches wide. For some distance above—say, for the basement and ground floor stories—the work will be hammer-faced with boasted dressings, the joints being somewhat narrower than those below. Then above, a similarly boasted face, with mouldings and dressings more finely worked.

The main entrance porches, colonnades, and pavilions, however, have finely boasted face, with chiselled mouldings and dressings. As can be readily conceived, the variations of surface treatment, associated with the judicious setting of stones, must mean a valuable contributory factor to most acceptable texturing And while diamond saws, frames, and other forms of stone-working machinery, driven by electricity, will figure largely, it is the intention that practically the whole of the surface-treatment shall be attained by hand.

There is one point of design, however, in this connexion in which I think the conventional might have been yielded to advantage, and that is in the adoption of "ante" treatment at the terminations of columnar portions, at least to the extent of mouldings returned on themselves at cap and base levels. The reason for the absence of such response is far from apparent, especially as some of the angles, allied or otherwise with colonnades, are conspicuously emboldened by quoins breaking bond.

Supremacy of feature must unquestionably be given to the roof covering, and its continuity is of that order which Professor Bryce has referred to as "desperate." For not only is parallelism obtained with its base and summit lines, but by means of ridge-flats there has been secured an equality of slope throughout. With a deeply imbued sense of the climatic conditions of summer-tide in South Africa's interior, the unique mass of roofing overhangs the wall face some 5 feet; and the whole result is a tremendous simplicity allied with a very full measure of purposefulness.

The covering is of the ordinary half-round red tiles, of which some 18,000 square yards will be demanded from the provinces of the Union of South Africa, for they are to be made in this country, and the ends of the lowest course will be visible after the manner that gave rise to the ante-fixae of the Greeks.

Beneath these overhanging eaves will be seen an apparently almost endless succession of heavily moulded teak sprockets. Their close proximity, however, to the caps of the columns and the soffits of the upper window heads, with nothing of the nature of a frieze intervening, is the perplexing feature of the design; and that to which any criticism I may feel called upon to offer is mainly directed. To have introduced the accepted architrave and frieze of the Ionic order would have meant a little less direct shadow within pavilion and office, but summer-tide does not prevail throughout the year; and the effect of such height of plain surface would mean intensity of shadow, and some appreciative additional verticality at the conjunction of two primary factors of the design.

Now, a specially good item in the contract is its liberal provision for the expenses of setting up full-sized models for any features so desired, in order to enable further and more comprehensive thought prior to their embodiment in permanent form. Already some revision of minor features is taking place, and there is every promise that this opportunity for temporary modelling in actual positions, will mean much in the perfecting of the design. My principal hope is that it will mean the revision of the work beneath the main eaves in the direction stated, even at the expense of the loss of moulded stonework at this point.

Summarising the design elevationally, it would appear that some more dominant feature than has been provided for is essential to pull the exceptional stretch of roof-surface together. It must be remembered, however, that owing to the site occupied, for all practical purposes from wherever seen, the horizontality of roof-surface will be lost. The curvature of the central block will present a great catenary dip into the Kop's side; and this, with the end pavilion bays, by reason of their projection and consequent hipping, will mean the breaking of the visible surface vertically as well as horizontally. At comparatively near distance, and particularly as viewed from the axial line, either from the summit of the Kop or from southwards, the foregoing features, allied with the twin towers, will accentuate the strength of simplicity, and result in a sky-line of an exceptionally bold order.

In matter of detail there is also very full evidence of much devoted attention. The results, however, are quite a psychological study. For instance, in one direction is to be found the most restrained relieving of surface, as in the pedimenting of four window heads of the southern front; a studied reticence that gives just the touch of beauty to sternness, as in the bracketting of balconettes; while in another direction poetic fancy seems rather to have outrun itself, in the shaping of the tops of the keystones, gargoyled outlets, and bits of tiled weathering on moulded stonework.

Internally there is also much of the same dual exhibition of restraint and revelry, and in the latter direction the impress of the architect's partiality for the early art of Cape Colony forcibly abounds, perhaps most strikingly in the lantern treatment of the fanlights of the principal doorways. On the other hand, hardly any plate-glass enters into the scheme.

Indeed, both the ardent enthusiast of plainness and the lover of minutiæ will find over these great stretches of wall-surface and floor area a considerable amount of satisfying detail.

And it is specially gratifying to all who take an interest in artistic expression to note that the art of sculpture is to be afforded worthy representation in niched recesses (externally and internally), courts, amphitheatre, and tower heights,—a sum of £20,000 being earmarked in the present contracts towards this purpose.

Then, I think some information as to the preparatory work involved in this great scheme, as well as some material facts in regard to its bulk and scope, will not be without interest.

To record the amount of mental labour on the part of the architect, and of his staff, and also the officials of the Public Works Department associated with the scheme, is impossible. But a crude idea of the extent of their work may be gleaned from the extent of the drawings and allied documents upon which the tenders for the work were based. (And from these there may be also realised something of what the preparation of a tender for a large building means to a contractor.)

As two of the blocks are practically identical, and form one contract, they can be taken as a whole, though various points (and the desire for separate tenders) meant considerable additional work. For each of these blocks there are thirty-five large sheets of drawings, a specification of some seventy foolscap pages of printed matter, and a bill of quantities containing over 2,600 items set out in 133 similar-sized pages.

For the central block a separate specification and a set of drawings of fully equal magnitude, and involving numerous points peculiar to itself, were prepared; and also a bill of quantities that ran into over 2,000 items.

During the progress of the foregoing documents, and the preparing of tenders, the Government accomplished a considerable amount of earthwork, or rather principally rockwork, in the way of the formation of a definite plateau for building operations, roadways, and protection from storm-water.

Following upon this the tenders of Mr. M. C. A. Meischke were accepted for the eastern and western blocks of £310,500 and £312,000 respectively, and that of Messrs. Prentice and Mackie for the central block at £256,224, making contracts that total £878,500.

The contractors have now for some months been in possession of the site; and plant, temporary structures, shedding and materials, in conjunction with roads, tram lines, electrical power and native compounds, are asserting themselves; while arrangements are in full swing for the supply and manufacture of the vast quantities of material that will be required. It is estimated that close on £40,000 will be expended on plant alone. The enormous masses of concrete now being deposited in foundations will absorb some 200 tons of steel and iron-work; while for floors, columns, piers, girders, arches, ceilings, vaulting and staircases about 36,000 square yards of steel reinforcement are required. For stancheons, joisting, and bars the rolling mills of the world will be called upon for nearly 600 tons. Necessarily, the whole of this metal-work will have to come from the Older World; and to the forests of Europe and America we must look for most of the timber, and to the Mediterranean basin for the decorative marble (though some South African marble is included); yet, to a fuller extent than ever before in South African history of a single structure, material from within its own British borders will be demanded. Some indications in figures I have already given, for instance, that nearly 4 acres of roof tiling are to be so forthcoming. The Union territory is also called upon for the manu-

facture of over 11,000 square yards of floor and wall tiling, in addition to large quantities of drainage and sanitary ware.

But long ere the stages of tiling and lavatory basins are reached there will be worked upon the site a quarter of a million cubic feet of freestone, from specially selected quarries opened up for the purpose; tons upon tons of Portland cement and lime disposed of (each of which, though not specified to be South African, will, I understand, be supplied very extensively, if not exclusively, from works and kilns in the neighbourhood of Pretoria). And some 12 millions of bricks will enter into the requirements, for which a number of new kilns are being laid down. And for the conveyance of all this material into position, probably not less than 50 cranes will be in operation at once.

Most of the pavement is of South African material, either granite, stone, slate, or granolithic; and locally made red Dutch Klomje bricks are outstanding features in chimney-piece settings.

As to joinery, there will be extensive workshops upon the site, and in the immediate neighbourhood, fitted with electrical appliances, which also means that this important branch will have fullest supervision during the progress of manufacture.

South African stinkwood enters into some of this joinery, and Rhodesia—a prospective member of Union—is asked for a measure of the teak supplies.

It is also interesting to note that India will furnish the teak block flooring for the Conference Room, Reading Room and Library; and that the Commonwealth of Australia will be represented in the paving blocks upon which the Ministers of State will set foot as they are about to enter their stately vestibule.

And I think the probabilities are that Canada will at least aid with the heating installation; so to complete the web of Empire, room must be found for at least a specimen of the exquisite woods of the Dominion of New Zealand!

Then, in addition to the material in the actual buildings, there will be thrown out, under the present contracts, masses and vast areas of rough stone from the surrounding mountains, rock-faced granite, and wrought freestone in pavements, terraces, balustrading, fountains, and plant-settings, steps, shelters, acess-subways, motor and cycle housings and roadways; as well as an amphitheatre equalling in accommodation the ancient Odeum on the slopes of the Acropolis. And while there will be a quiet charm in these essentially surface features, yet, as allied with the various bastion-like stretches of masonry necessitated by the rising mount, there will also be the contributing of a further sense of graceful strength to the structural background. But before closing this paper there must be some attempt to visualise more fully the natural and prospective setting of the composition which I have sought to represent.

Northward, some 500 feet to the rear, stand, as sentinel-like guards the double-breasts—typical inland South African rises—of Meintjes Kop, bronze-browned, with a handful of shrub-

like foliage sparingly scattered. The summits, some 300 feet above the level of the southern boundary, are easily accessible.

From the western side a few homesteads dot the slope to the brook-like river that virtually marks the extent of the city proper; and eastward, between the boundary and Government House, a distance of a mile, lie well-wooded suburban residences. Church Street, pre-eminently the thoroughfare of Pretoria, at an altitude well above the centre of the city (though distant therefrom little more than a mile), constitutes the southward limit, and means a foreground of about a quarter of a mile square.

Entering the grounds at the S.W. angle, a tramline, without encroaching on the foreground to any extent, reaches a roadway parallel to the building, and some eighty feet away. From this level, about 100 feet above Church Street, the ground floor is attained by subways and easy flights of steps. But a higher level road, to which motor-cars and other vehicles can travel, conducts directly to the porches at the main entrances.

Then a further road winds its way beyond the line of the actual foreground to the northern central entrance at the principal floor line, designed primarily for the Governor-General-in-Council and for Ministerial purposes. Executive accommodation mainly centres on that level; and I understand it is the intention to continue this highway to Bryntyrion, where Government House is situated and official residences cluster.

The compulsory axial line upon which I have already dwelt strikes Church Street obliquely, and in the direction of the city, which means that, while enhancing the view, the charm of approach therefrom is sensibly increased.

The sketch plan of the site has been prepared by the architect, and at the intersection of the axial line with Church Street shews a central entrance, presumably for foot passengers only, as no provision has been made in the lay-out of the street for entrance otherwise. This opens on an area the full width of the foreground of about a quarter of a mile, and extends about halfway to the buildings—a length of about 200 yards—having at this early summer-tide almost the appearance of a billiard table.

Through this an avenue of noble proportions leads to a circular piazza, whose dimensions rival many of those of Continental order. Beyond, a gradual terraced and stepped slope conducts to the level of the tram road. On either side there are set out subsidiary pathways and spaces on symmetrical lines. No doubt the best available authorities will be consulted as to detailing those grounds; which may well be styled the Union Domain, and the circular space the Piazza of King Edward the Peacemaker. Let that piazza be graced with an heroic monument to South African Unity (of the nature of that which so enriches Turin); a few dashes of sculpture by the nation's best artists, scattered about the grounds; here and there cascaded masses of water in splendid basins; and broad masses of dwarf trees, with expanses of green turf; and the whole arranged with a signifi-

cant simplicity in harmony with a stately slope, a worthy foreground cannot but result.

It has been said :

"It is within the power of the man who deals with soil and trees to surround our buildings with an impression and indefinable atmosphere appropriate to the hour and the future."

and such a man must be in evidence here; but there must also be right to the end of this scheme the controlling mind that recognises, not only that the focus is supremely architectural, but that the far-flung lines of masonry so heroic in South Africa's history compel an amplitude of treatment in every direction. In the residential areas of the city that stretch o'er plain and slope in carpet-like formation, there are necessarily displayed multiform features which should remain without a rival; and all the temptation to cherish display on other than the broadest lines on that Union site must experience the fullest restraint.

I have often heard it suggested that other buildings might suitably find place within that foreground, but surely no such encroachment on the setting of this South African structure will ever be permitted. But as to the background, I believe the summit will eventually be crowned with a memorial structure, not primarily to mark an historic event, but in response to the call of the north for some visible expression, on the height that intervenes, of the national character that has found so full emphasis southwards. And an index to that northern stretch will be obtainable across the saddle of the Kop, towards the north-east and north-west respectively, from the lunettes in the drums of the tower domes.

In the matchless Table Mountain with the environment of the sea, the Legislative capital of the Union of South Africa has a natural grandeur, with which no efforts of human endeavour can ever compete; yet, in the subject which I have endeavoured to portray, the Administrative Capital will possess a distinctive feature. Watching the setting sun (or, as the Greeks would say, "His rejoining of his kingdom"), I have found that a feeling of romance akin to that of classic heights is not entirely absent from that altitude; and no doubt while many are destined to enjoy therefrom "the open spaciousness and clear skies" (to which Lady Gladstone recently referred as characteristics of the Transvaal), this Kop of Meintjes, with its architectural possession, will also rank as a southern shrine for pilgrims of art, and add to the themes of poet and painter, and, no mean asset of Empire. Children in whom is writ the power to rule, will be attracted there to admire the view, to gain "a comprehensive vision of the wide outlook, and to cherish the seeing below the surface of things."

For the heartiest co-operation in the preparation of this paper, on the part of Mr. Herbert Baker, the architect; of heads of various branches of the Public Works Department associated with this great scheme and of the contractors, I am especially grateful.

LOGICAL LABO... WOODS HOLE

CHEMISTRY AND CROPS.

By Arthur Stead, B.Sc., F.C.S.

It may be thought, and perhaps said, with much truth, that the subject of this paper has been discussed until everyone is heartily sick of it. It is therefore with no little hesitation that I now seek to raise a further discussion on it.

Were I not convinced that the more this subject is brought to the public notice the easier will be made the advance of this branch of agricultural science, I should not have ventured to submit this paper for consideration and, I hope, discussion.

The first article of our association states that one of its objects shall be to remove disadvantages of a public kind that may impede the progress of science. I think no one will disagree with me when I say that there exists at the present time a very serious and obstinate impediment of a public nature hindering in no little degree the advancement of the chemical investigations of the soils of this country. I speak of the unwillingness of our people, through their governments, to spend adequate sums of money for the prosecution of such studies. It is indeed strange that sufficient funds are not forthcoming wherewith to study that on which our very existence depends, *viz.*, the soil. What has already been done? In the Cape, Juritz, after twenty years work, has not been able to survey more than one-tenth of the soils of that Province. In the Transvaal, Natal and the Free State, practically nothing of a systematic character has been accomplished. No doubt much of the public apathy is due to the fact that there still lingers a good deal of prejudice among agricultural scientists regarding the utility of chemistry as a means of measuring soil fertility. This prejudice is largely founded on ignorance, and is accentuated by confusion. It is high time that the last cobwebs of doubt and mistrust were dispelled. As an endeavour to that end, I beg to place before you the salient points of this important subject with the hope of gaining your active sympathy. I do not ask nor expect that there will be unanimous agreement with respect to the views which I shall put forward; but I do trust that a full discussion of this vital matter will be raised, and that in the end this Association will be able to lend its persuasive support to those who are striving for the thorough investigation of our soils.

Agriculturists owe Liebig a great debt of gratitude for having put before his contemporaries in a most forcible and authoritative manner the conclusions to be drawn from the work of Schübler, Boussingault, Priestly, Saussure and others. It is no exaggeration to say that Liebig's report to the British Association in 1840 and his subsequent chemical letters on the same subject created a profound impression in the minds of the agricultural chemists of that day, for, no doubt, they thought they had very reasonable prospects of being able to determine the measure of soil fertility in their laboratories; but, alas! it was not to be. The problem

has not, even now, 70 years after, received its final and complete solution. These past 70 years have been years of strife—one feels inclined to say unnecessary strife. Almost all the trouble has arisen from the persistent confusion of and the fruitless endeavours to combine two related but different problems, *i.e.,* (1) The determination of the immediate productivity of soils that have long been subjected to the operations of cultivation, and (2) the determination of the permanent productive capacity of virgin soils. Of the two problems, the latter is the simpler, and should have been tackled first; but, unfortunately, such an one did not present itself in theo only continent where there was a scientific activity, *viz.,* in Europe; for all the lands there had long been under the plough. This was indeed a pity, for it certainly resulted in the defeat of chemistry as an aid to agriculture.

Going back to Liebig's time, I will briefly allude to the various stages in the evolution of our present day methods. The first step commenced with Liebig's assertion that if sufficient quantities of the ash constituents of plants were present in the soil good crops would be obtained. Soils were therefore subjected to vigorous analysis, with the result that, as often as not, analysis and cultural experience told very different tales. The strong acids and fluxes which it was then customary to use as solvents were able to extract, even from exhausted soils, quantities of plant food materials largely in excess of the requirements of crops. It is, therefore, not to be wondered at that the analysis of soils came to be very much discredited, and looked upon as a waste of so much time and money, that ever since many writers have been at great pains to prove its uselessness. The natural and violent reaction against chemistry led to the practical abandonment of soil analysis, and for a time cultural experiment was looked upon as the only means of salvation. But salvation did not so much as come in sight; it was soon found that, in practice, this method was one of very limited utility.

Agriculturists once more turned to chemistry for enlightenment, and obtained it; for chemistry had not been idle—it had not been repulsed by one defeat; but had gained strength therefrom, and had quietly set out to win by other methods of attack. It had been found that the use of weak-acid solvents gave much more reliable indications of immediate productivity. Among the pioneers may be mentioned Dehérain, who was able to obtain, using dilute acetic acid as a solvent, reliable indications in cases in which strong acids had signally failed. This was indeed a triumph, and led to further experimentation with other weak acids, among them citric acid, which, in Dyer's hands, gave very gratifying results. Dyer was able to announce, as the outcome of his investigations, that if a soil be extracted with 1 per cent. citric acid for 7 days, and if it were found to contain not less than .01 per cent. phosphoric acid and .005 per cent. potash, then only did the soil contain sufficient quantities of these materials for the production of good cereal crops.

The use of dilute organic-acid-solvents was a piece of remarkably good fortune, and may be attributed to the then universal belief that such acids were secreted by plant roots, and

that it was by their solvent action on the soil particles that the plant obtained its food in solution. Dyer estimated the average acidity of the sap of roothairs as being equivalent to 1 per cent. citric acid, and from this determined the strength of his solvent. Dyer's method has come to be looked upon by many as a fundamental one, and by such people the amounts of plant food ingredients extracted by it are called the "available" amount. For my part, I consider the method one of great utility; but find myself quite unable to urge that it is in any sense a fundamental one. That it cannot be fundamental is evident from many facts. For example, the minimum limits assigned by Dyer are yet much in excess of the actual requirements of any crop; the limits are too high for soils of warmer climates; the method gives very unreliable results with ferruginous soils and with calcareous ones, unless a sufficient extra quantity of citric acid is used to neutralise the lime and magnesium carbonates. This means *if the method is fundamental,* that when grown on calcareous soils a plant is able to secrete additional quantities of acid. But it would appear from Ingle's investigations that Transvaal soils are generally deficient in lime carbonate, and, further, that Dyer's limits for these soils are too high. This means *if the method is fundamental,* that an absence of acid consuming substances diminishes the activity of the acid solvent, which is absurd. Therefore, the method is not fundamental. Its great utility can be accounted for without making any extravagant assumptions; one only needs to assume that Dyer's solvent has in very many cases a power closely related to the solvent agencies of the soil. That Dyer's method is not a fundamental one could also be inferred from the fact that deci-nomial nitric acid has been found by some chemists—notably French and American—to be a more reliable solvent than citric acid; whereas nothing could possibly be more reliable than that which is fundamental.

I do not wish to make extravagant claims for chemistry, and therefore do not claim that we have yet come across a fundamental method of determining the immediate productivity of long cultivated soils; but the making of such a statement in no wise detracts from the great value of such methods as have been elaborated, and have been used with undoubted success in every part of the world. Our knowledge of the methods by which plant food materials are rendered soluble in the soil has of recent years been very much enlarged. The statement that plant roots secrete acids other than carbonic acid goes no longer unchallenged, and it appears to be very probable that there are no acid secretions other than the one mentioned, provided the plants are grown under normal conditions. Even if other acids were secreted, it seems to me that they must play quite a subordinate part in the formation and solution of plant food materials. When one calls to mind the well-established possibility of materially increasing the store of available plant food by means of a bare fallow; the considerable solvent action of carbonated water not only on lime and magnesium carbonates, but also on undecomposed rock minerals of all kinds; the instability of zeolites to-

wards neutral saline solutions, and the fact that normal vegetation thrives but poorly on soils that are only slightly acidic, there is little need to call upon plant roots to secrete acids in order to extract their daily wants from Mother Earth.

How profound this action of water on the soil particles is may be gathered from the extensive accumulations of soluble salts in soils that are not subjected to natural leaching as, for instance, those of arid countries. In irrigation areas soils that have shown no signs of "alkali" at the commencement of irrigation operations have had to be abandoned in a few years owing to excessive saline accumulations, which it is impossible to account for solely by the composition of the water used. In America not less than 10 per cent. of irrigated lands have had to be abandoned for this reason.

Now, what is this accumulation of alkali? It is the accumulation near the surface, owing to faulty methods of irrigation, of soluble salts that have been liberated from the insoluble soil particles by the hydrolytic and chemical action of the irrigation waters. Therefore, it would appear that *the* great solvent agency at work in the soil is water, which in turn is aided in its operations by the atmospheric agencies and by soil organisms. Some such considerations as these possibly induce King and others to attempt to measure soil fertility by extractions with pure water. King's experiments have certainly produced very promising results; his method may be said to be fundamental except in so far as it does not represent all the conditions that obtain in the soil, notably the influence of time, the action of soil organisms, the varying concentration of the soil solution, together with its effect on the zeolitic plant food reserves, and the continual removal of salts from the sphere of action by plant roots.

The heating of the soil as practised by King is quite an arbitrary operation; but it probably compensates in some measure for those natural conditions which it is impossible to imitate successfully in the laboratory.

We have now passed over the achievements of chemistry as regards the measurement of the immediate fertility of soils. To sum up, it may be said that we cannot yet claim to have reached the long-desired goal; but we are just about to get there. Above everything rises this fact, that given a soil whose physical conditions are such as will not interfere with the proper development of the plant, the chemist is able at the present time to determine with considerable accuracy its immediate productive capacity, whether it belong to the virgin class or that class which has been subjected to the operation of cultivation for an indefinite number of years. This is no slight achievement.

Let us now turn to the second problem mentioned above, *viz.*—the ascertainment of the future behaviour of a virgin soil for a number of years to come, or, in other words, the determination of the permanent productivity of soils. It is obvious that the methods used for the ascertainment of the immediate outlook will not suffice. The methods adopted must be such as will extract from the soil the total quantity of plant food materials that may be expected to come into solution within a given inter-

val of time. This is the chief problem that presses for solution in countries that are yet only sparsely settled. In buying a house one takes into account its probable life and cost of upkeep; so, also, in buying a farm one should be able to ascertain how long the soil will continue to produce good crops, and what will thereafter be the probable cost in fertilisers necessary to maintain its production. This depends primarily upon the quality of the soil, *viz.*, on its chemical and physical characteristics. So important a point is soil quality that Dr. Wm. MacDonald,* in reducing the various points of a farm to the score card, gives it no less than 20 per cent. of the total marks, and no doubt if it were not for the fact that proximity to railway and market makes fertilisation a practical undertaking, the number of marks so assigned would have figured very much higher. It is this second problem, this ascertainment of the permanent productive capacity of virgin soils, which is of especial importance to South Africa, for most of our land is yet in its virgin state. Let us now see how far chemistry is able to help us in its solution.

If the various states in which plant food occurs in soils be considered it will be found that there is a water-soluble portion, a zeolitic store and a yet unearthed mineral reserve. Under the influence of the natural agencies the mineral reserve is daily contributing to the production of the water-soluble and zeolitic stores, both of which are readily available to the plant, especially the former. It is evident that cropping, and perhaps drainage, will continually reduce the water-soluble and zeolitic forms; but the rapidity with which this occurs will depend on the rate of transformation of the mineral reserve. This rate will evidently depend upon the activities of the natural agencies, and also to a greater degree upon the amount of and the fineness of grain of the unweathered mineral particles. Further, it follows that given similar conditions, the greater the original amount of the mineral reserve in a soil the larger will be the stores of zeolitic and water-soluble forms at any subsequent date. If this be accepted, it must also follow that virgin soils which show high percentage of plant food materials are bound to be fertile, and lastingly so. Therefore the problem the chemist has to solve in dealing with the permanent productivity of a virgin soil is one of finding a solvent that will dissolve a maximum amount of all three forms of plant food materials. Such solvents are nitric and hydrochloric acids. The advantages of the latter acid are so numerous that there is no need for me to mention them here. It is the one that has been used by Hilgard and Loughridge in America for the past 40 years with distinct success. Hilgard† writes of the method as follows:

> "It seems to be generally true that virgin soils showing high percentages of plant food as ascertained by extraction with strong acids, invariably prove highly productive; provided only that extreme physical characters do not interfere with nominal plant growth, as is sometimes the case with heavy clays, or very coarse, sandy lands. To this rule no exception has thus far been found."

*See Transvaal Agricultural Journal.

†E. W. Hilgard: "Soils: their formation, properties, etc." p. 343

To come nearer home, Juritz, whose method of extraction is similar to that of Hilgard and Loughridge,* after about 20 years' experience of Cape soils, writes that the results obtained by him are in good agreement with the results of cultural experience.†

The method of storing acid extraction demands that the operator take into account the results of cultural experience, for it is only by so doing that it has been possible to determine what are high precentages of plant food and what are good, bad or indifferent soils. In this country we have a grand opportunity for correlating chemical analysis and cultural experience, for none of our lands have been so long cultivated that the principal features in their history have been forgotten. Especially will it be remembered what native vegetation they bore when first put under the plough; how long the first flush of production lasted, and what kind of crops they have since borne. Further, since the native vegetation of soils is mainly determined by soil and climatic conditions, it should be easily possible to pick out to-day virgin soils that are similar to those which we have cultivated for the last 30 or 40 years. Once this has been done and the typical soils analysed, it will be possible to say with much certainty what our cultivated soils were like before they were broken up, and what will be the future behaviour of those that are about to be taken in hand. Close attention should also be given to the study of the botanical, physical and geological characteristics of the typical soils, and their features correlated with their chemical composition would lead to the discovery of the actual causes of the observed vegetative preferences. Once in possession of this knowledge we should be able to recognise with certainty the capabilities of soils on which native vegetation was either absent or not characteristic. This would result in the prevention of the enormous waste of time, energy and money that obtains to-day in vain endeavours to grow particular crops on soils that are naturally unsuited to bear them.

Enough has been said to indicate that if we are to obtain the fullest measure of help from chemistry in the elucidation of the problems related to the fertility of South African soils, it is necessary that a very comprehensive soil survey be undertaken at once. It should even include a biological study of the soil for, in the light of Russell and Hutchinson's recent researches on partial sterilization of soil (which is a natural occurrence with us) as a means of promoting nitrification, such a study is sure to furnish results of no little importance, and will no doubt explain why in arid countries nitrogen as compared with phosphoric acid is of secondary importance. It will have been noticed that the methods of analysis described are not calculated to deal with a nitrogen adequacy or inadequacy. This particular subject is really of minor importance, for it is within our power, provided a soil is well furnished as regards mineral plant food constituents, to build up a nitrogen store by methods of good farming.

* C. F. Juritz: "Agricultural Soils of Cape Colony," pp. 12, 13.
† pp. 13, 17.

We have now considered chemistry as an indicator of soil fertility. It is also extremely valuable in pointing out causes of sterility other than those which depend on an insufficiency of plant food materials. For example, in certain parts of this country the periods of drought are so extensive and the amount of rainfall so slight that the total products of weathering remain in the soil, and frequently attain to sufficient dimensions to give rise to the condition known as "brak," viz., the visible occurrence of saline matter in the soil. Such excessive quantities of soluble salts are very deleterious to the growth of ordinary crops, and for certain crops very much smaller quantities of saline compounds than are indicated by their visibility would be fatal or inhibitory. Little has been done towards the investigation of these, our richest soils, but in America and India much work has been acomplished. The subject is a large one, and cannot be discussed here; therefore I would refer any who desire information on this subject to the writings of Hilgard and to the bulletins of the United States Bureau of Soils. May I urge upon you who, because of your climatic conditions, have little or no interest in this special branch of agricultural chemistry that the study of saline soils, if it does nothing else, will certainly broaden your view of the chemical reactions that must occur in soils of humid lands. Particularly applicable to this country are the writings of Juritz* and Stead† bearing on this subject. These would probably be profitably perused before the other publications mentioned. Some recent work, too, by Osterhout (California) is also important to students of this subject. He has shown that salts are mutually antagonistic in their effects upon plants, which opens up the possibility of treating "brak" lands by appropriate additions of requisite salts. Enough has been said to indicate how indispensable is the help of the chemist if we are to bring our rich "brak" lands under economical and profitable cultivation.

That many other advantages would accrue from a systematic and thorough chemical investigation of our soils is very possible. Take for example our stock diseases and our insect pests. It is important to know whether soil composition has any influence in these directions. Long ago Juritz suggested that the prevalence of lamziekte in certain districts of the Cape Colony was closely connected with a notorious deficiency of lime and phosphates in the soil. Ingle has laid stress on the abnormal ratio of lime to phosphoric acid in the general diet of our stall-fed animals. Of late writers have urged that white bread, with its lack of phosphates, has a predisposing effect as regards tuberculosis in man. Dogs have been fed on phosphorus deficient rations, and have become unhealthy and ill-developed. Further, it is known that certain inorganic elements inhibit while others again promote phagocytosis. Finally, we feed bones to our cattle, which crave for them, while we ourselves consume tonics consisting largely of phosphorus and other inorganic elements.

* "Soils of Cape Colony." pp. 172-187: also Report of the Robertson Irrigation Congress, 1900, pp. 64-70.

† Trans. Phil. Soc., O.R.C., 1908; also Reports of Director of Agriculture, O.R.C., 1907-8 and 1908-9.

What do these facts point to if not to the great importance of the mineral constituents of foods in the maintenance of the health of man and beast? How is it possible that our food should contain sufficient quantities of these substances if our soils be lacking? Is it not folly to continue to ignore this aspect of soil investigation?

In turning to insect pests we find that our wheat crops are frequently ruined by the wheat louse; that the depredations of "green fly" make us wish we had never planted peach trees in our orchards. Of course the biologist tells us that at such times as the insect gains the upper hand its natural enemies have been quiescent. This is certainly only a part of the truth, and no doubt exists in my mind that it is not the most important part. Judging from the analogies of nature, one would think that a plant-sap pre-eminently suitable as food for these little creatures is the main cause of their occasional alarming multiplication. If this be the correct interpretation, the devastation wrought by them will ultimately be traced to soil conditions which need not be, and probably are not, of a permanent character. In Bloemfontein sweet peas sown after October almost invariably receive much damage from infestations by an aphis. As a matter of routine, in connection with some experiments I made with a view to promoting the development of bacterial nodules on the roots of legumes, I examine the roots of all legumes grown in my garden. In those cases in which sweet peas have been most damaged by the aphis I have frequently noticed that there has been a very considerable development of the bacterial nodules, which suggests that the plant has received more nitrogen than was good for it. This may be only a coincidence, but at the same time it appears to be of sufficient interest to warrant its being placed on record.

Very much akin to the depredations by aphides are the attacks on grasses and cereals by rust, which, by Hall, is said to be due to a sudden excessive nitrate production in the soil. The same writer mentions a very interesting fact about mangel leaf-spot fungus. This fungus invariably attacks crops grown on plots that have been manured excessively as regards nitrogen. Further, it would appear that whereas this fungus thrives well on a pulp made from healthy leaves grown on such plots, it does not do so on a pulp made from leaves grown on plots receiving a normal plant-food ration. It would therefore seem that soil composition may have much to do with the causation of plant diseases and insect depredations. It behoves us to find these things out.

I must now conclude; but before doing so let me say that I am aware of many shortcomings in my paper, for which I would ask indulgence. Further, may I hope that I have succeeded in accomplishing that which I set out to do, i.e., to show the great importance of chemistry as the hand-maiden of agriculture, and to enlist active sympathy in the removal of those obstacles that are impeding the progress of its successful application to the problems connected with the soils of this country.

THE TRANSFERABLE VOTE IN MUNICIPAL ELECTIONS.

By John Brown, M.D., C.M., L.R.C.S.E.

The object of the use of the transferable vote is to secure that as far as possible every vote given may be used for the election of the representatives, so that the thoroughly representative character of the elected body is secured.

In our present system the return of a member depends on his securing a relative majority of the voters in his ward or constituency. Less than half the votes given are usually effective in returning members, so that the resulting elected body is far from representing the voters.

In boroughs sometimes one party secures a monopoly of the representation, and the Royal Commission* points out that the English House of Commons barely represents, even approximately, the relative numbers of its electors. Half a century ago, Hare and J. Stuart Mill recommended the sectional representation of the people, the representation of minorities as well as majorities, and of any section able to give the man of its choice a quota.

For English-speaking communities the Royal Commission considers the transferable vote most likely to secure confidence, and it recommends it for Municipal Elections. . . *Sections* 1-6.
In securing its object the voters' work and that of the returning officer is simple. . . . . *Sections* 7-15.
Two elements of chance and the means of obviating them are considered. . . . . *Sections* 16-19,
The Cape Provincial Elections, Senatorial, and the Municipal Elections at Cape Town and Johannesburg are considered. . . *Sections* 20-25.
Then, the evils of the present system, and the probable influence of the new system on the Ward, the voters and the candidate are considered. . . . . , *Sections* 26-30,

SUBJECTS OF SECTIONS.

1. Effective and non-effective votes.
2. True representation.
3. Election by a relative majority—our present system.
4. The Royal Commission or Parliamentary representation.
5. The object of Hare and J. Stuart Mill now attained in the Transvaal.
6. Other plans. The Royal Commission on the transferable vote for Municipal Councils and second Legislative Chambers.
7. The object of the system, and the voters work under it.
8. The work of the returning officer, and the quota.

*Report Cd. 5, 163, 1910.

9. The Town Council, an administrative body, and its proper majority.
10. The successful work of the returning officers at Pretoria and Johannesburg.
11. Method of the English Municipal Representation Bill in the Transvaal, and that of Gregory in Tasmania, for the Parliament.
12. Illustrative example of the former method in distributing primary surplus from original votes in the first count.
13. Illustration of distribution of a secondary surplus from transferred votes of a member's surplus, or an excluded candidates' votes.
14. Distribution of the votes of excluded candidates corresponding to non-effective minority votes at a present election.
15. Final process when one candidate more than the number of members to be elected alone remains.
16. The slight element of chance in distributing a surplus.
17. The method of obviating it.
18. Another element of chance in distributing votes of excluded candidates.
19. How Gregory's method satisfactorily obviates this.
20. Peculiarities of South African Senatorial Elections.
21. Cape Provincial Senatorial Election, 1910.
22. Cape Town Municipal Election, 1909.
23. Johannesburg Municipal Election, 1909.
24. Composition of unused votes, 10 per cent., and other particulars.
25. Johannesburg Municipal Election, 1910.
26. Evils of present system.
27. Position of the Ward under the new system.
28. How the transferable vote affects the voter.
29. How it affects the candidate.
30. Advantages of its extension in promoting true representation. (See Section 2.)

1. In this paper we shall consider three recent elections. In doing this a few preliminary remarks or explanations may assist us.

In the recent parliamentary election in the Central Division of Cape Town, the successful candidate got 1,695 votes, a majority of 1,399 over his opponent, who got 296 votes. Now one more vote than 296 secured his return as a member; the 296 votes his opponent got were, so far as the election went, useless, non-efficient, and every one of the 1,398 votes that the member got over and above the 297 which returned him, were in like manner, so far as election went, needless, useless, non-efficient. They showed what a very deservedly high opinion his fellow citizens held regarding him, but so far as election went they were thrown away. They were non-effective majority votes; while his opponent's were non-effective minority votes.

The fewer of these non-effective votes we have in an election the better; the more effective votes there are the more representative does the elected body become, in the sense of resembling and so representing the constituency, the greater is the number of

voters who are pleased at having returned a member, the more confidence does the member feel in the discharge of his duty, the more interest does the voter take in his member's doings and sayings. Yet as a rule, under our present system of election, considerably more than half the votes given are non-effective ones. In the Cape Town Municipal Election that we shall consider the percentages of the three classes, effective, non-effective surplus, and non-effective minority votes, were 42, 13 and 45 respectively, giving in all 58 per cent. of non-effective votes.

2. The best and truest representation is obtained where we have a good and efficient choice of well qualified candidates, a large number of voters interested in the election and the doings of the Council, a large proportion of efficient votes electing a member, who will exercise an independent and unfettered judgment. The greater the share in the election of the member that falls to the intelligent voter the better.

3. Our present system of election is by a "relative majority vote"; 297 votes were sufficient in the election I have mentioned; in a close contest in another constituency with the same number of voters it might have required five times as many votes to ensure election. Every election entails a competitive contest, a struggle for victory, a fight, in fact, with all its inevitable attendant evils; and the results are usually anything but satisfactory, and entirely fail in electing a representative council. In the triennial elections in the London Boroughs in 1906, in Bethnal Green, Fulham and Lewisham for all the seats in the Councils, a monopoly representation of 30, 36 and 42 members, was returned, not one of the other four parties securing one single representative in any one of these three boroughs.

4. As to Parliamentary representation, the Report of the Royal Commission appointed to inquire into Electoral Systems, published this year,* says of the last seven Parliamentary Elections from 1885 to 1910:—

"Only in one case, the election of 1892, can the actual results be said to represent approximately the balance of voting power possessed by the two parties. If these conclusions are checked by the figures for contested elections only, they are merely confirmed. In the contested elections of 1895, a Conservative majority of 77 was returned by a minority of 25,000 voters. In England, in 1906, an unusually cogent example, because out of 465 seats only 20 were uncontested, a Liberal majority of 200 members was returned by a margin of voting strength which only warranted a majority of 55."

These are the results of our present system of election.

5. Fifty years ago Hare and John Stuart Mill raised the cry for the election of the best men, and one vote one value.

Their solution was to substitute for majority representation by a "relative majority of votes," the sectional representation of all parties, proportionally to the number of votes their adherents cast. In a city of ten wards and ten thousand voters, instead of ten annual Ward fights, or one triennial city contest, settled by a "relative majority" in each case, they would have had ten members, each elected by one thousand voters. Say there were three parties in the city, "A" with 6,000 voters, "B" with 3,000 voters,

*1910. Cd. 5,163.

"C" with 1,000 voters, they would have had six members of the Council elected by the "A" party, three by the "B," and one by the "C."

Now, fifty years after, thanks to the evolution of electoral methods, and mainly to Lord Courteney's ability, patience and persistence, the South African cosmopolitan town of Johannesburg realised, as nearly as possible, this very ideal on the first occasion on which they used the transferable vote, securing thus one vote one value, and the election of the ten best men among the candidates, and the representation of the minority as well as of the majority, and of any section of the ratepayers numerous enough to secure the election of one member.

Three other plans to secure these objects are the Limited Vote, the Cumulative Vote, and the Belgian System; the first two are abandoned in England. We had the cumulative Vote, working easily and well, in our Cape Colony late Legislative Council elections. The third holds the field and makes way in Belgium, both in Municipal and in Parliamentary elections.

The Royal Commission Report I have already quoted* says after examining these three systems:—

"73. If then any system of proportional representation is to be regarded as likely to command aceptance under the existing conditions of our political life, it must be the Transferable Vote." [It says in Paragraph 135:] "As we have already pointed out, the system shows at its best in elections, where the comparative merits of candidates as individuals are at issue. Thus there would be much to be said in its favour as a method for the constitution of an elected Second Chamber. Again, though it is no part of our reference to consider the applicability of the Transferable Vote to non-legislative bodies, we may observe that many of the most important objections to its use for political purposes are not valid against proposals to employ it where the functions of the body to be chosen are primarily administrative. . . . . . The Municipal Elections at Johannesburg have quite recently been held with marked success under the Transferable Vote."

7. The object of this system is to secure that as far as possible every vote shall be effective, shall help the return of one member.

Under this transferable vote system the voter's work is very simple; in place of marking a cross "x" opposite the name of the candidate he wishes to vote for, he marks the numeral "1." In doing this he secures for himself and the chosen candidate all that they enjoy under the present system. He may stop there if he chooses; all else is a voluntary exercise on his part of a privilege he may employ. His vote already given may be effective, or it may be one of a non-effective surplus, or one of the useless, non-effective minority votes for a candidate, who can never hope to come in, whose candidature becomes eliminated. If he has intelligence enough to express his preferences for other candidates and wishes to do so, he may secure that his vote goes to help the election of that very one among his selected candidates, who needs it to secure his return. The voter simply places opposite as many candidates' names as he chooses the consecutive numerals 2, 3, 4, 5, etc., having already, as I say, placed "1" opposite the candidate's name, where now he puts "x," a cross. The more preferences he expresses the more surely does he secure his object.

These expressed preferences enable the returning officer to transfer the vote to the candidate to whom it can be of use if the first name on it is that of a candidate already elected by the time that vote is used; or is the name of a candidate already excluded, because he was lowest on the poll; and thus all non-effective votes of the present system can be made effective and the member receives more than double the number of votes that fall to his share now.

8. The work of the returning officer requires careful study of and attention to the rules, by which the at present non-effective surplus votes are distributed according to the voters' preferences, and so made effective with mathematical correctness and precision, and the experiences of these officers at Johannesburg and Pretoria show that with due care this work can be easily done in a short time. This done, he has so to distribute the at present non-effective votes of the unsuccessful candidates, rendering them also effective.

The quota, or minimum number of votes a member must obtain to secure election, is found by adding one to the quotient, got by dividing the number of valid votes by one more than the number of members to be elected. Thus if 100 voters have to elect one member, we divide 100 by 1 + 1, that is by 2, and add 1 to the quotient, which in this case is fifty, giving us fifty-one; which number the successful candidate must secure. If there are two members to be elected, we divide 100 by 3, getting on the addition of one, 34. We neglect fractions, and work only with whole numbers, we have one vote one voter, and the voter cannot be divided. If the two members get 34 votes each out of 100 votes, only 32 votes are left for the next highest candidate, two less than the quota, so he cannot get in. This number, which is the minimum number the member must secure in an election, is called the quota; it is the minimum number which makes a candidate's election secure, and it is the number of votes which all members, as far as possible, must secure in elections under the system of the transferable vote.

9. In the town council we have most distinctly an administrative body, to whom the ratepayers hand over the control of matters common to them all, such as matters relating to streets, buildings, water supply, sewage, lighting, locomotion, public parks and all sanitary matters and other common interests.

These common interests will be best administered when the council, as fully as possible, represents, in the sense of resembling, the ratepayers, the whole of the ratepayers, not merely a majority of the ratepayers, or ten ward majorities.

The majority must and will rule, but the minority are entitled to their due proportional representation on the council, and the majority on the council should be proportionate to the majority of the voters; and it is to the advantage of the town that this should be so; and also that all sections of the ratepayers numerous enough to give a member the quota should have one as their representative.

In Cape Town the ratepayers are divided into three classes according to the value of their property, and the voting papers of these three classes are marked as giving the value of one vote,

two votes, or three votes, respectively. At the election in 1909 the respective numbers of these three classes were 1,996, 1,430 and 1,934. So that, in comparing this election with the Johannesburg one, I give the percentages of Cape Town votes, which average about double the number of voters. In Johannesburg the numbers of votes and voters are identical.

In the example I quoted above, of a city of ten thousand voters distributed in three parties, "A," "B," "C" with 6,000, 3,000 and 1,000 voters, respectively, an election of the whole city for ten members, each voter having the right to give one vote for each of the ten members, would have resulted in the return of all ten members belonging to the "A" party, had the voting been on strictly party lines, even if the "B" and "C" parties voted together. The majority would have had a monopoly of the members, as in the case of the three London boroughs in 1906 which I mentioned.

10. I now come to my last preliminary explanation, and will attempt to show how Mr. J. Taylor, Town Clerk of Johannesburg, managed in eight and a half hours to give expression to the preferences of ten thousand five hundred and forty voters, concentrating on ten members ninety-eight and a half per cent. of the votes that were capable of transfer, and that had been given for twenty-two candidates; how, in fact, he managed to carry out the ideals of Hare and John Stuart Mill; which was done at Pretoria also with complete success.

11. There are two methods used for the transfer of non-effective surplus votes, that of the English Municipal Representation Bill, 1908, adopted in the Transvaal, and a second method, Gregory's Method, adopted in the Tasmanian Electoral Act of 1907, and used in their general election last year with great success.

In the first of these the member retains his quota of all the actual votes and voting papers; and as many as possible of the surplus votes and voting papers are given proportionally to the next available preference candidates.

In Gregory's method the member retains such a share of the value of each voting paper as will give him his quota; and all the voting papers are marked with their remaining value, and distributed at that value, proportionately, to the candidates marked on the voters' voting papers as the next available preferences.

12. English Municipal Representation Bill Method. Suppose there are seven candidates, "A," "B," "C," "D," "E," "F" and "G," whose votes decline numerically in order from "A" to "G"; suppose that the quota is three thousand, which "B" gets, while "A" has five thousand voting papers, on all of which other preferences are marked. Suppose, further, that "D" has 2,250 votes. Proceeding, on the Transvaal method, to distribute "A's" non-effective majority of two thousand, we take all the five thousand votes in "A's" parcel and distribute them in sub-parcels according to the next available preference marked on them. We put all on which "C" is the next available preference in one parcel, and so with "D," and so on. "A," with his surplus, and "B" with his quota, have been elected. "B" is no longer an available preference, and his name is now passed over whenever it occurs on

a voting paper. On three thousand of "A's" voting papers, suppose that "C" stands as next available preference, and that on two thousand "D" is the next available preference. We have now to find out how many of these 3,000 votes in this sub-parcel of "C's" are to be retained by A towards making up his quota, and how many can be transferred to "C." "A's" share of the whole 5,000 votes he got is 3,000, three-fifths. We have taken all these 5,000 votes and made two parcels of them; one, "C's" parcel, with 3,000 votes; one, "D's" parcel, with 2,000 votes: out of each parcel we must keep for "A" three-fifths, which is his quota, his share of the 5,000 votes given for him. Thus "A" will get three-fifths of the 3,000 votes in "C's" parcel—1,800, which leaves "C" 1,200. "A" also gets three-fifths of the 2,000 in "D's" parcel, 1,200, leaving "D" 800. Both "C's" share and "D's" share are equal to two-fifths of the number of "A's" share, on which they respectively had the next available preference.

Now two-fifths or $\frac{2{,}000}{5{,}000}$ represents the surplus number of available preferences.

In practice we use this fraction as a multiplying fraction,— $\frac{\text{surplus}}{\text{available preferences}}$ and by this fraction that amount of "A's" total votes, which each candidate receives, as the next available preference, is multiplied, to show what number ofvotes fall to his share. The results above were whole numbers, but often we get fractions in addition to the whole numbers. The rules tell us only to transfer whole votes and to neglect fractions, which necessarily leads to the loss of one vote in every case where fractions occur. In Mr. Taylor's first division he had to divide a non-effective surplus of 80 votes among 15 candidates, and 8 votes were lost through this neglect of fractions, only 72 being transferred, and as far as possible made effectvie.

So much for the distribution of original or primary surpluses.

13. If "D's" sub-parcel, with its 800 votes, added to the first votes he got, which are in his original parcel, give him a surplus, he retains only that number of the transferred votes, 750, which will give him the quota, the remaining part, 50 of "A's" original surplus, of which he received 800, being passed on in the same way as before to those candidates who now occupy the place of next preference. This is merely a continuation of the distribution of "A's" surplus, in which "D's" original first votes have no concern whatever. Such is the method of transfer of surpluses, secondary as well as original or primary.

14. The distribution of the minority non-effective votes is a very simple matter. When all surplus votes have been distributed we take the candidate lowest on the poll—in our supposed case "G," and as his chances of being returned are lower than those of any other candidate we exclude or eliminate him, and distribute his votes according to the next available preference expressed on each of his voting cards.

15. This process is continued till we have only one more continuing candidate than the number of unelected members. At Johannesburg, after the 15th transfer, there were four continuing candidates, while three members had still to be elected. The

lowest of these four candidates was excluded without examining or transferring his votes, and the other three were declared to be elected.

16. The rule for the transfer of secondary surpluses in the English Municipal Bill, 1908, reads as follows :—

"4. l. g. The particular votes transferred from each subparcel shall be those last filed in the sub-parcel."

If "D" required 750 votes to give him the quota, only 50 of his 800 votes would be taken for further distribution, the fifty votes last filed. Now, here an element of chance occurs, for the next available preferences on these special fifty votes are not necessarily the same as those on any other special fifty votes of the 750 votes left in "C's" sub-parcel.

In the Johannesburg election there were only 73 out of 116 votes in the three sub-parcels, giving secondary surpluses, which were afterwards distributed. Yet even this slight chance is eliminated in the Tasmanian "Electoral Act, 1907," and in our Senate elections, by adopting the Droop system rule of redistribution for secondary surpluses arising from transferred votes, just as it is used for the distribution of surpluses from original votes.

17. This element of chance is removed in the simplest possible way, by extending to all secondary surpluses the same rule, "Droop's," which we have seen is employed for primary surpluses from original votes in Section 11.

In the Johannesburg election of 1909, three parcels of excluded candidates' votes gave the quota to three members, say, "A," "B," and "C." These parcels contained 25, 67 and 24 votes, 116 in all. The members required 3, 26 and 14 votes respectively, 43 in all. These 43 votes were left unexamined at the bottom of the transferred parcels; the votes at the top, the votes last filed, 22, 41, 10, 73 in all, were distributed to other continuing candidates. Now the next available preferences on the retained 43 voting papers may probably not be the same as those on any 43 of the 73 which were distributed. This constitutes the element of chance, which is got rid of by treating these surpluses exactly as is done in the case of original surpluses. (See Section 12).

18. Another element of chance is present under the regulations of the Municipal Bill. If "A's" surplus is being distributed and part of it, determined by the number of times "B" was marked second preference, goes to "B" with the loss of one vote through neglect of fractions. That one vote, and the votes "A" retains,, are finally dealt with. "B's" share of votes may have to be distributed, if "B" comes to be excluded, to the next available candidate. It is improbable that the third preferences on the votes retained by "A," and those transferred to "B," are identical. So here again an element of chance occurs.

This element, latent in every distribution of a surplus, is entirely removed by Gregory's system of retaining practical values for "A," "B," and so on, even to the ultimate final act of distribution.

19. Gregory's method of distributing all surpluses.

In place of giving, as we did, "A" his share of votes, and "C"

and "D" their share of votes, that is, the share of actual voting papers, Gregory gives "A" that proportional share of the value of each vote, which will secure him the quota, and distributes all the actual votes "at their diminished value," to the several candidates marked as next preferences, and on the sub-parcels he marks this diminished value, in our case two-thirds. He gives "A" $\frac{3,000}{5,000}$ or three-fifths of the value of each vote, three-fifths of 5,000 votes = 300 votes in value; "C" gets 3,000 of these A votes in a sub-parcel, marked as containing votes each of the transfer value of two-fifths:—two-fifths of 3,000 votes = 1,200 votes in value. "D" gets two-fifths of 2,000 votes = 800 votes in value in a sub-parcel similarly marked with a transfer value of two-fifths for each vote. "Transfer value" is defined as "that portion of a vote which is unused."

In the case supposed above (Section 13), where "D's" sub-parcel gave him the quota, and a surplus of fifty votes, the future value of two-fifths in each vote would be modified, as "D" would retain what value he required from every vote he received to give him his quota, and every vote would be passed on with its new fractional value something less than two-fifths.

Under the Johannesburg rules we suppose that "D" required (Section 13) 750 votes to make up his quota, so he retained them, and only the fifty last filed were taken out for further redistribution. So, under the Gregory method, "D" retains $\frac{750}{800}$ or 15-16ths of the value of the votes in his sub-parcel. That value was, we saw, two-fifths. "D" retains 15-16ths of 2-5ths or 30-80ths of each of these 800 votes, and all of "A's" votes that were in "D's" sub-parcel, that is, 800 of them, are now marked with a value of 1-16th of 2-5ths or 2-80ths = 1-40th, and at this value are redistributed to the next available preferences. "A" used up 3-5ths of the value of each vote, that is, 48-80ths, "C' 'used up 30-80ths; the transfer value, that is, "the unused portion" of each of these 800 votes is now 1-40th, and this is marked on each sub-parcel of those that are redistributed.

20. In the Senatorial elections we have small constituencies electing relatively large numbers of members, and so the quotas are very small; in the two smaller provinces in future elections 42 voters will have to elect eight members with a quota of five. In such cases the loss of votes by the neglect of fractions becomes a very serious matter. To obviate this, provision has been made to treat each voting paper as of the value of 100. Thus, in the Transvaal, where 84 voters had to elect eight senators, instead of the quota being $\frac{84}{8+1}+1=10$, we get $\frac{8,400}{8+1}+1=934$. This comes to the same thing as working out the division to two places of decimals. Gregory's fractional system of distributing all surpluses is also adopted in these elections.

We turn now to the elections.

21. In the Cape Province Senatorial Election, 1910, 132 voters had to elect eight members from over twenty candidates. There

were 87 voters of one party, "A," 42 of another, "B," and three Independents.

Voting in the usual way, the "A" party could have returned all eight members, even had the Independents voted with the "B" party.

If the voting, under the new system with the transferable vote, were on strictly party lines, the "A" party was sure of five members, and the "B" party of two; for any candidate who got 15 votes was sure of his election, provided the electors put his name first on their voting papers. As each party happened to have twelve votes over, in addition to their five and two quotas respectively, it was possible for the Independents, or any two of them, to give the eighth member to either party. The result was the return of six of the "A" party and two of the "B" party, and we got the eight men most preferred by the electors. Every voter voted, the large remainder of 12 over eight quotas, which 132 gave, made the largest possible percentage of votes that could be effective 91 per cent. This was secured; and we may be pretty sure that each of the 12 votes which necessarily were not used, contained the name of at least one of the members. The result was as satisfactory as it could possibly be, the members representing the two parties as nearly proportionately as the numbers permitted. And almost certainly the name of one member at least was on every voting paper.

22. In the Cape Town Municipal Election of 1909, about 5,000 voters in seven wards elected seven members from seventeen candidates. The Citizens' Guild and the Ratepayers' Association each ran a ticket, and secured five and two members respectively. The effective votes were 42 per cent., the surplus, non-effective votes 13 per cent., and the minority non-effective votes 45 per cent. The successful candidates received 55 per cent. of first votes and about 39 per cent. of the voters on the roll voted. Thus only 16 per cent. of the voters on the roll elected the members by their effective votes.

23. In the Johannesburg Municipal Election of 1909, the Transferable vote was tried for the first time, for electing ten members from 22 candidates, the town voting as one constituency. 11,788 valid votes were given, the quota was 1,072, and the remainder over ten quotas was 1,068, only six less than another quota, 9 per cent. of the votes, so that the utmost possible percentage of effective votes was 91 per cent. of all the valid votes given.

Johannesburg Municipal Election, 1909.

	Percentages.		*Number of Votes*
The members got	67.5	of all the votes as effective first votes	7,957
There were	1.1	of surplus effective votes	132
There were	20.8	of minority effective votes	2,451
	89.4		10,540
There were	10.6	of unused votes	1,248
	100		11,788

The members thus received 89.4 out of a possible 91 per cent. of all the votes, 98.2 per cent. of what was possible, although any effective next available preferences for three out of the ten members elected, which were in the 766 votes of Hewson, the last continuing unsuccessful candidate, were not examined or distributed.

24. These unused 10.6 per cent. (1,248) include 766, all the votes given to the last continuing unsuccessful candidate, 456 exhausted preferences, and 26 votes lost through fractions. Had these 766 votes been distributed we would have got an effective percentage of votes still greater than 89.4., which however, is only 1.6 less than the utmost possible 91 per cent.

A ticket of ten candidates was run, which secured 6,185 votes, just 247 less than six quotas. They got this number, 247, from Independent candidates' preferences, and returned six members.

The Labour party ran three candidates, and polled 2,126 votes, less than two quotas by 18 votes, which they received, thus returning two members; and two Independents secured election.

Thus the ten members fairly represented the electorate, and it is probable that many of the 1,248 unused votes contained the names of one or more members marked on them.

25. JOHANNESBURG MUNICIPAL ELECTION, 1910.

	Percentages.		*Number of Votes.*
The members got	58.4	per cent. of all votes as effective first votes	7,197
There were	14.5	per cent. of all the votes as effective surplus votes	1,798
There were	14.4	per cent. of all the votes as effective minority votes	1,770
	87.3	per cent.	10,765
There were	12.7	per cent. of all the votes unused	1,563
	100.0		12,328

As the remainder given by 12,328 over 11,210, ten times the quota is 1,118, only three less than another quota, nine per cent. of all the votes: only 91 per cent. were capable of use. The above 87.3 per cent. represents 96 per cent. of all the votes possible to be used. These expressed wishes were all influential in securing the election of the members, and compare with 42 per cent. in Cape Town in 1909.

26. The most serious evil of Municipal elections under our present system is the apathy, indifference, aloofness, of the vast majority of the ratepayers, and the unwillingness of good men to come forward as candidates. There is a tendency for voters to abstain from voting; they seem to look on the result of the election as a foregone certainty, and to think that their votes would only swell a secured majority, or be thrown away with the minority. Those who know say that half the voters, who do vote, would not do so unless they were driven to the poll.

Lately in Cape Town some seventeen items, involving an expenditure of nearly a million and a half—£1,463,000—was sub-

mitted to the voters for their vote. No carriages were provided in this case, and the total votes given on any item did not exceed 2,110; representing about half that number of voters, less than 8 per cent. of those on the roll, though one item was £366,000 for improvement of streets. It was hoped that the return to the ward system last year would excite interest. It seems to have failed to do so, for only 39 per cent. of the voters on the roll voted; and only three wards were contested this year at its second trial.

27. Under the system of sectional representation it would be impossible for any candidate to canvass the whole city. It is to his own ward and his own locality he could most profitably devote his attention, and all the advantages of the ward system without some of its most striking disadvantages, might be retained. Nomination, canvassing, the present system of election, can all continue. If some local need is strongly felt the whole ward can put forward, and secure by its votes, the election of their best local man; all he needs is the support of a quota.

28. Surely the knowledge that 89 per cent. or more of the votes given are effective in place of 42 per cent. as now, the knowledge that placing the best candidate in order of his preference on his voting paper will secure the election of that one of them who most needs his vote, and the opportunity of choosing any one of all the candidates who stand for election, will in time, tend to diminish the apathy and increase the interest of the voters, who now have merely an alternative offered to them of voting for one of two local ward candidates, neither of whom it may be they would have chosen as representing their views or wishes.

29. The unwillingness of candidates to come forward is partly due to the expense, the work and the worry of personally canvassing for votes; to the thankless want of appreciation on the part of the voters for the services their members give them; to the unpleasantness of a contest with perhaps an inferior candidate with local influence, who wants, for his own sake, to secure election, who may have secured the support of the "boss" of the ward where there is one.

30. We know from recent revelations that in the election of members for Boards of Guardians in London, there is danger of the representation there falling into disrepute. We are free from this evil here, as we are free from the predominance of the party element in the election of our members of council. We most certainly need greater interest in both the election and the doings of our Town Councillors. The day is perhaps not far distant when we, in the Cape Peninsula, shall see most at any rate of our half-dozen outlying suburban Municipalities united; and before long, it may be, we shall have the privilege, which the Municipalities in the Transvaal enjoy, of applying for a reform in Municipal elections, that realises what John Stuart Mill advocated more than fifty years ago, and that promises to do something towards securing those essentials for true representation, to which I called attention at the beginning of this paper. (Section 2.)

THE SACRIFICE OF RECONCILIATION AMONGST THE BA-RONGA.

By Rev. Henri A. Junod.

When one studies the religion of the Bantu carefully, one finds something very striking in it. We are accustomed to consider religion as the sister or rather as the mother of morality. The system of Christianity combines these two departments of the psychic life in such a way that they are inseparable. A progress in faith calls forth a progress in sanctity, because God for us is the supreme Author of the moral law. Such is not the case at all amongst Bantu Animists. Their gods, the spirits of their forefathers, have very little to do with morality. They remain entirely indifferent to the conduct of their descendants; they do not give them any reward for good behaviour nor do they punish them for ordinary bad actions. Only when a man becomes a kind of Don Juan, keeps no restraint in his adulterous habits ,the Ba-Ronga say that the gods will lead him into a dense forest and kill him there.

However, I have found in certain customs of the Ba-Ronga some traces of an organic union between religion and morality; and, as I think we must welcome every ray of light amongst darkness, I venture briefly to describe my little discovery. Strange to say, I owe that discovery to a Christian song which is a favourite amongst our congregations and which was composed by one of the older missionaries of the Swiss Mission many years ago. This song glorifies the work of the Holy Ghost and implores Him, amongst other blessings, to *hahlela madjieta.* We always took this expression as meaning: to take away from the heart bad feelings, feelings of anger, of rancour. Such is indeed the usual signification of it. But on studying it more carefully with the aid of good informants, I found behind it a good many notions which I had never met with before.

There are two words to consider in this expression: *Hahlela* is a verb, the verb *hahla,* to perform a sacramental act, such as a sacrifice to the spirits. The suffix *ela* which is added to it is the desinence of the applicative derivative and conveys the idea of: "in relation with, in favour of." *Hahlele madjieta* means therefore: to accomplish a sacramental act in relation with *madjieta.* But what is *madjieta?* This is the plural of a noun of the class *dij-ma, djieta* pl. *madjieta.* It is met with under this form in the Ronga dialect of Delagoa Bay and becomes *rieta* pl. *marieta* in the Northern clans of the Thonga or Shangaans. *Djieta* is the "oath by imprecation" which one can pronounce under various circumstances.

Suppose a man goes to baths in the lake of Rikatla; there he is stung by something. He runs out at once and shouts: "I shall never again enter this lake, never, never, never"! This

solemn declaration is the djieta. Some time elapses; that man is called with all the other men of the district to go "*Ku tjeben,*" viz., to kill the fish in the lake. The water has dried up and the whole male population is summoned to a kind of fishing which is a favourite and very productive sport. All the fish being imprisoned in the small pool, the natives plunge into the water conical baskets opened at the top, cover the fry and catch the fish in that way. But the man who has pronounced a *djieta* dare not enter the water. He is bound by his oath. Should he break it he would meet with a terrible accident. To avoid this misfortune he must *hahlela djieta.* He will pray thus: "You, djieta, I had said that I would no more enter this lake, but I want to eat fish. Do not cause me to suffer from it." Then he takes some water in his hand and throws it into the pool.

Or suppose the same man has been followed by a crocodile when crossing the river; he has been very near death; yet having escaped, he utters the same words: "Never again shall I cross this river!" He has pronounced a *djieta.* When he finds himself again on the border of this river, obliged to cross it, he must conjure the calamity in that same way. If he does not do so, the boat will be unable to get through. It will only turn and turn again on itself and make no advance. The boatman will bring back the man who bound himself by imprecation, and he will have to pray to his *djieta* while he throws some water into the boat.

This prayer, it is strange to say, is not addressed to spirits of the ancestors, but to the imprecation itself as if the oath had become a kind of independent being who must be propitiated like a god. The water thrown is evidently a kind of offering. So far, the sacramental act which is performed has nothing to do with ancestor worship which is the religious sphere, properly speaking.

But suppose the imprecation has been pronounced against some member of the family; then, at once, the regular gods are affected by it in one way or another. Let me give two instances to show that connection:—

I. One of my informants, Mboza, told me the following story which is a very good illustration indeed. Mboza is the eldest brother of Komatane. He is a poor man, Komatane is rich. He has many daughters; amongst the Ba-Ronga that means cattle or pounds sterling. Mboza asks his brother to help him in his misery. But Komatane refuses to do it. He sells his daughters without saying a word. The elder brother gets angry; he reproaches Komatane for his unbrotherly behaviour. The younger brother does not accept these reproaches; he loses his temper and says: "You are a dog, a wretch! What I am eating is my own and it is no business of mine to help you. I shall never go again to your village"! In pronouncing these words Komatane has sinned (*doha*) gravely. He was the younger; to insult his elder brother by *djieta* was a great fault indeed. The two men avoid each other henceforth. But later on, Komatane falls into misfortune. Somebody is taken ill in his village and he throws the divinatory bones in order to know what he has to do. The bones reveal that he must offer a sacrifice to the spirits of the

ancestors; perhaps to a special spirit, and they order him to call his elder brother Mboza to conduct the religious act. Mboza is the regular priest of the family, being the first born. Komatane suggests another name. But the diviner insists. Komatane starts for the village of the offended brother and asks him humbly to come and implore the ancestors for him. Mboza consults the bones also. He is not disposed to go at once. Sometimes an offering, instead of appeasing the spirits, irritates them even more, and the man who has officiated comes back home trembling with fever! Let us see if the sacrifice is likely to succeed. The bones are consulted again; they answer: "There is something in the way. You two have tied a knot. Untie it first, then go, you." Mboza understands what it means. He sends this word to Komatane: "The fortune-teller does not allow me to go. He says we must first untie the knot." Then the younger brother who is the offender comes a second time. They discuss their case inside the hut, not on the square, as it is a personal and secret matter. Komatane confesses his fault: "It was not right of me to say: 'I will never come again to your village. I have sinned in this and this and this.' Then Mboza answers: 'You are a bad fellow indeed! How could you refuse to help me? Are you not the younger and am I not your elder?" He scolds him vigorously and everybody in the village does the same, even the women and the children. This being done, the quarrel comes to an end and Mboza goes with his brother to his village and offers the victim which shall appease the gods and deliver Komatane from his trouble. This special meeting of confession and reconciliation is the *hahla madjieta*. There has been no sacrifice, properly speaking, performed in this case. But in order to accomplish a religious act, it has been necessary first to reconcile a divided family. In this way the ancestor worship—in which the right of the elder brother as being the regular priest of the family is so universally admitted—has had a true moral effect.

II. But a second instance will lead us a step further. When two brothers quarrel, when one has sworn that he will never see the other again, when there is disunion between their kraals, they may be brought to the *hahla madjieta*, not only by the fact that one of them must sacrific for the other, but simply by the advice of the old men of the family. These old men will say to the divided brothers: "Our gods will punish you if you do not stop quarrelling! They do not line you to curse each other, being brothers. You must be reconciled to each other. *Hahletelanan madjieta,* viz.:* Perform together the sacrifice for imprecation." The two brothers decide to follow the advice. The one who pronounced the imprecation prepares a decoction of a special herb called *mudahomu*, a word which means the grass which the ox eats, because cattle are fond of it. He pours it into a *shikamba shansala*, that is to say into the broken shell of a

* The form *hahletelanan* is very instructive from the grammatical point of view and can be analysed as follows: *Hahla*—to perform the sacramental act. *Hahleta* (frequentative)—bringing to the light everything on which you disagree. *Hahletela* (applicative)—in relation with your imprecation. *Hahletelanan* (mutual),—one in regard to the other.

fruit called *sala* (Strychnos), as big as a large organge, and which is frequently used as a drinking vessel. Everybody meets on the *hubo,* the square of the village, and the two enemies sit in the midst, on the bare ground, and not on a mat. The offender lifts the shell to his lips, takes a sip of the decoction in his mouth, spits it out, making the noise of *tsu.* This *tsu* is the sacramental syllable by means of which the Ba-Ronga call their gods to the sacrifice. However, he does not pray to the spirits as is done in regular offerings. He only says: "This is our imprecation! We have pronounced it because our hearts were sore. To-day it must come to an end. It is right that we make peace." The other brother, the offended one, then takes the shell in his hand, and after having gone through the same rite of the *tsu* says: "I was justly angry because he first offended me. I have been irritated myself also. But let it be ended to-day; let us eat out of the same spoon and drink out of the same glass and be friends again." Then he breaks the shell, and if there is a Banyan store in the neighbourhood, they buy two bottles of Portuguese wine and drink them together!

In this second case, a true sacrifice has been performed and the act of reconciliation bears a strongly religious character. The gods have been more or less summoned as witnesses, and the enemies have become friends again because they feared to be punished by the spirits of their ancestors. The religious feeling has certainly inspired a moral act.

But should a man pronounce an imprecation against a stranger, *viz.,* against a man who has not the same ancestors, no such reconciliation would be possible. A man's gods have no reason whatever to interfere with people belonging to another family. The religion of the Ba-Ronga is strictly a family affair. The jurisdiction of the gods does not extend further than their direct descendants, and the moral influence of the religious beliefs of Ancestrolatry is limited, therefore, to the narrow sphere of the family. This shows that we cannot expect amongst those animist tribes anything like the spiritual morality of a theistic religion.

TRANSACTIONS OF SOCIETIES.

CHEMICAL, METALLURGICAL, AND MINING SOCIETY OF SOUTH AFRICA:—Saturday, December 17th: J. Moir, M.A. D.Sc., F.C.S., President, in the chair.—"Notes on Matte Assay": L. J. **WILMOT.** The author advocated the use of a matte for the removal of base metals as of the greatest value in gold assaying, and in illustration described his method, with results obtained in the assay of such articles as copper drillings. Details were also furnished of experiments made on rich copper matte and on litharge dross carrying 20% of copper.

FERTILISERS FROM THE OCEAN.

By MARSHALL LUNDIE and ROBERT WIENAAR HALLACK.

The use of sea plants as manure was common on the coast of the Mediterranean in ancient times, but the ancients had observed that the sea-weeds had to be washed with fresh water, because they saw that the sea-salt adhering to the weeds was not beneficial to the soil.

A large number of sea plants occur widely diffused throughout the whole ocean covering our planet and are washed on to the coasts. In many parts they are employed for other purposes besides being used as fertilisers. The ashes are employed for the manufacture of " Barilla Soap " in Spain, and for the extraction of Bromine and Iodine in England and in France. Kelp, or sea-weed ash, prior to the discovery of the Stassfurt Salts, was largely employed for the preparation of Potash Salts, and was at one time the principal source of Soda. It was then valued as highly as £20 per ton.

A. D. Hall, in his work on " Fertilisers and Manures "* says :

"Off the South and West coasts and in the Channel Islands, sea-weed forms the staple manure, being collected after heavy weather and laid up in heaps to dry and rot. On the heaviest soils it is sometimes ploughed in immediately after gathering just as 'long' dung is used on clays to open up the soil."

The same author gives us some analysis of sea-weeds used for manure in Jersey :—

	FUCUS.	LAMINARIA.	SEA GRASS.
Water	30.50	52.80	22.60
Organic Matter	51.30	30.00	59.10
Containing Nitrogen ...	1.56	.70	.52
Ash	18.20	17.20	18.30
Containing Phosphoric Oxide	.50	.43	.62
Containing Potash ...	4.50	3.70	.56
,, Sand ...	.86	.54	2.80

"Thus even the poorest of these samples is in the wet condition about as rich as ordinary farmyard manure, while the FUCUS would be valued as highly as £2 per ton.

This statement of Mr. Hall's our farmers living near the coast should take to heart.

Dr. Edward Heiden mentions in his " Coprology "† the following sea plants as of special importance in agriculture :—

1. *Fucus Vesiculosus.*—Of general occurrence in the Ocean.
2. *Fucus Serratus.*—North Sea and the Baltic.
3. *Fucus Nodosus.*—Throughout the Atlantic Ocean.
4. *Laminaria Latifolia.*—In the North Atlantic.
5. *Laminaria Digitata.*—In the North Atlantic.
6. *Furcellaria Fastigiata.*—Very generally found in all Oceans.

* Page 75.
† Vol. 2, page 415.

7. *Rytiphlaea Pinastroides.*—In the Atlantic Ocean.
8. *Fucus Crispus.*—Throughout the Atlantic.

He gives* some interesting analyses :—

	WATER.	NITROGEN	ASH.
Fucus Vesiculosus	70.57	.32	5.37
Fucus Nodosus	74.31	.28	4.89
Laminaria Digitata	88.69	.15	5.46
Furcellaria Fastigiata	80.44	.45	10.31

The ashes of these sea plants contained :—

	LIME.	POTASH.	OXIDE. PHOSPHORIC.
Fucus Vesiculosus	8.92	20.75	2.14
Fucus Nodosus	9.60	20.03	1.71
Laminaria Digitata	7.21	5.55	2.42
Furcellaria Fastigiata	7.74	20.24	1.72

The author adds :—

"These analyses prove that the manurial value of these plants is very considerable. They are distinguished by the large amount of Potassic Oxide and Nitrogen, whilst the quantity of Phospboric Oxide is somewhat low, for this reason it is advisable to use broken bone or bone-meal together with the sea-weed in order to supply the soil with these three essential constituents of plant food in the proper proportion."

All plants require as plant food the following substances :—

Sulphuric Oxide.	Carbon Dioxide.	Magnesic Oxide.
Phosphoric Oxide.	Water.	Calcic Oxide.
Nitrogen.	Potassic Oxide.	Ferric Oxide.

Of these, Phosphoric Oxide, Nitrogen and Potassic Oxide are not present in sufficient quantity in the soil, and must therefore be supplied as manure. For the coast districts of the Western Province the quantity of Lime is of special importance, as the soil is singularly deficient in this essential constituent. It may not be amiss here to enumerate briefly the more important functions that these important constituents perform in plant life.

Phosphoric Oxide.—This constituent is found in all soils, and a soil is said to be rich in Phosphoric Oxide if it contains as little as .1 per cent. From the lowest to the highest class of plants all contain Phosphoric Oxide. It participates in the formation of albuminoids, and as these are formed in the young leaf it is evident that the young leaf contains more Phosphoric Oxide than the old leaf, and hence requires when young a source of this constituent to draw upon. At a later stage the Phosphoric Oxide passes from the leaves to the stem and seed of the plants and is replaced in the leaves by Silica. This explains the fact that seeds of plants are richer in Phosphoric Oxide than any other part. Phosphoric Oxide has a distinct ripening effect, and besides this it stimulates the development of seedlings in young plants. As an example of the amount of Phosphoric Oxide required by plants we give the following :—

From 1 acre of land Wheat takes in the seed and straw 21 lbs. of Phosphoric Oxide.

From 1 acre of land Potatoes take in the seed and straw 29 lbs. of Phosphoric Oxide.

* Op. cit., page 417.

From 1 acre of land Tobacco takes in the seed and straw 32 lbs. of Phosphoric Oxide.
From 1 acre of land Lucerne takes in the seed and straw 39.1 lbs. of Phosphoric Oxide.

Potassic Oxide.—Potassic Oxide in the plants takes part in the formation of Starch and Sugar, and it passes with the Carbohydrates (Starch and Sugar) from cell to cell. It is associated with the Starch and Sugar in the plants in a similar manner as Phosphoric Oxide is associated with the albuminoids. To this is due in a great measure the success of viticulture in the Western Province, as our soil, being formed by the disintegration of granite, is rich in Potash.

With reference to Potassic Oxide in the plants the following facts have been ascertained.

All those parts of plants in which vegetable growth is proceeding are rich in Potassic Oxide. Wherever the formation of a new cell goes on in the plant—buds, young shoots, young leaves, freshly formed bark, cambium tissue—Potassic Oxide is the preponderant inorganic constituent. Young leaves and parts of plants always contain more Potassic Oxide than old leaves. The Potash compounds in plants have a tendency to migrate into those parts where work is to be performed. In the young leaf the ashes consist essentially of Potassic Phosphate and Potassic Carbonate, while in the old leaves they consist of Calcic Oxide and Silica.

The leaves of plants contain more Potassic Oxide than other parts of plants. Hence all plants full of leaves, such as herbs, clover, grass, tobacco, hops, vegetables, cabbage, etc., contain large quantitites of Potassic Oxide.

All plants and parts of plants in which a considerable amount of carbohydrates is stored up also contain a very large amount of Potassic Oxide. As an example of the amount of Potassic Oxide required by various plants we give the following :—

From 1 acre Wheat takes 30 lbs. of Potassic Oxide.
From 1 acre Tobacco takes 60 lbs. of Potassic Oxide.
From 1 acre Lucerne takes 107 lbs. of Potassic Oxide.
From 1 acre Potatoes take 108 lbs. of Potassic Oxide.

Calcic Oxide or Lime.—Lime is absolutely necessary for all plants in all stages of development. It takes a prominent part in the transformation of sugar and starch into cellulose. It also gives a certain firmness to old leaves. Many diseases in crops and plants are solely due to want of Lime. The addition of Lime to a soil accelerates the decomposition of organic matter in the soil and assists in rendering all the constituents of manures and fertilisers available to the plant.

It destroys the acidity of the soil by neutralising the organic acid formed in a sour soil. It decomposes very energetically the unavailable mineral constituents of the soil and changes them to combinations in which they can be absorbed by the plants.

It acts on the debris of rocks, rendering the Potassic Oxide in such mineral matter more available to the plants, and this would be an excellent manure for a granitic soil.

Lime also acts on the physical properties of the soil by altering stiff and cold clays into loose and warm loams, so that air as well as moisture can freely percolate through the soil.

As an example of the amount of Lime taken up by plants we give the following:—

From 1 acre of land Wheat takes 8 lbs. of Lime.
From 1 acre of land Potatoes take 31 lbs. of Lime.
From 1 acre of land Tobacco takes 121 lbs. of Lime.
From 1 acre of land Lucerne takes 186.3 lbs. of Lime.

The subject of using sea-weeds as a manure attracted our special attention when we observed the large quantities of sea-weeds thrown up on the coasts of the Colony. We have been informed that many years ago attempts were made to use these sea-weeds for the extraction of Iodine, and some Kelp was prepared near Sea Point and sent to the Iodine Factories in Glasgow, but it has been given up on account of the great expense. To our knowledge sea-weed is at present not being used in agriculture in South Africa together with or in place of farmyard manure. Since climatic conditions, the chief of which is the temperature of the sea water, influence to a great extent the growth of sea plants, we have carried out a series of investigations with a view to ascertaining the compositon of those sea-weeds which we observed in largest quantities.

The sea plants were taken fresh from the sea to the Chemical Laboratory of the South African College and examined immediately with reference to the amount of water, which may appear more in our analysis than in those mentioned above in which the material was not so fresh as in our case. Some of the sea-weeds were collected on the Sea Point beach, near the contact zone of the Granite and Slate formations, and others were gathered on the beach at Muizenberg and Kalk Bay. Analyses are given of sea-weeds whose botanical names were kindly supplied by Prof. H. H. W. Pearson, Sc.D., F.L.S.

	Water.	Organic Substance.	Nitrogen,	Ash.
Sea Grass ... ... (*Enteromorpha Intestinalis*)	77.44	17.64	.567	4.80
Algae ... ... (*Ulva Lactuca*)	78.04	18.8	.35	3.16
Fucus Palmatus ... ("Sea Bamboo")	86.42	8.71	.071	4.87

The ashes of these substances contained:—

	Lime.	Potash.	Phosphoric Oxide
Sea Grass	28.58	16.01	4.48
Algae (Sea Point)	28.96	11.34	5.57
Algae 1st sample (False Bay)	19.87	—	6.9
Algae (2nd sample (False Bay)	21.78	9.5	9.98
Fucus (Sea Point)	9.48	30.9	6.59
Fucus (False Bay)	7.16	44.31	3.87

If the composition of the air dry sea-weeds be given we should have :—

	Sea Grass.	Algae.	Fucus.
Water	22.260	21.96	13.580
Organic Constituents	78.430	85.150	64.064
Nitrogen	1.648	1.590	.522
Lime	6.154	4.171	3.314
Potash	3.414	1.630	11.045
Phosphoric Oxide	.965	.801	2.326
Insoluble Silica	5.525	.469	.073

Since sea-weeds contain a large amount of Potash they would prove to be an excellent manure for vines and cereals.

The amount of Nitrogen present is also large, indeed it is a common theory that the vast fields of "Chili Saltpetre" were produced by the oxidation of immense masses of sea-weeds. Nitrogen is one of the important constituents of plant food, besides costing more than any of the other necessary constituents of a fertiliser. When applied to the soil it has a very direct and immediate effect on the growth of the plant and also acts as a stimulant in the cold weather. Many experiments have been carried out to show that the plant cannot utilise the vast amount of uncombined atmospheric nitrogen for its nutrition, and thus the nitrogen must be supplied to the soil in a combined state.

In Europe, where the sea-weeds are so largely employed for agricultural purposes, they are left to dry in heaps near the beach and are then carried away to the farms, weighing about one-fifth of the weight of the fresh sea-weeds. Here they are made into heaps with the farmyard manure, in which they rapidly decompose.

H. J. Webb, in his *Agriculture,* says :—

"The best method of using sea weed as a manure is to form it into a compost with marl or shell sand and turn it once or twice. It rapidly decomposes in the land and when ploughed in fresh into clay lands lightens them considerably."

Now, shell sand is easily obtained on our beaches, and this method should prove particularly effective in the South-Western Districts of the Colony on account of the large quantities of Lime which would be brought on to the soil naturally deficient in that substance. The action of sea-weeds upon the physical properties of the soil is highly beneficial, since the large amount of vegetable mould which is added to the soil greatly improves the water retaining power, and allows air and moisture to percolate more fully through the soil. While in some cases "Chili Saltpetre" and the "Stassfurt Salts" have been found to have a somewhat injurious action on the physical properties of clay soils.

Sea-weeds are superior to farmyard manure inasmuch as they are entirely free from seeds of weeds or spores of diseases, and hence ensure a clean culture.

We hope that the grain farmer in the South-Western Coast Districts will pay some attention to this subject, by which he can obtain at very little cost an excellent manure for all cereals, potatoes and root crops.

Going into figures, and taking the value assigned to Tricalcic Orthophosphate, Potassic Oxide and Nitrogen in Hall's "Fertilisers and Manures," page 340, et seq., we obtain the following results :—

1. Sea Grass.

	£	s.	d.
Phosphoric Oxide = .965 per cent.			
Tricalcic Orthophosphate = 2.242 at 1s. 11d. per unit per cent.	£0	4	2
Potassic Oxide = 3.414 at 1s. 4d. per unit per cent.	0	14	3
Nitrogen = 1.648 at 12s. per unit per cent.	0	19	9
Value of one ton = ...	£1	18	0

2. Algae.

	£	s.	d.
Phosphoric Oxide = .801.			
Tricalcic Orthophosphate = 1.86 at 1s. 11d. per unit per cent.	£0	3	6
Potassic Oxide = 1.63 at 4s. 1d. per unit per cent.	0	6	8
Nitrogen = 1.59 at 12s. per unit per cent.	0	19	0
Value of one ton = ...	£1	9	2

3. Fucus.

	£	s.	d.
Phosphoric Oxide = 2.326.			
Tricalcic Orthophosphate = 5.400 at 1s. 11d. per unit per cent.	£0	10	4
Potassic Oxide = 11.045 at 4s. 1d. per unit per cent.	2	5	1
Nitrogen = .522 at 12s. per unit per cent.	0	6	2
Value of one ton = ...	£3	1	7

It appears from the above that a ton of the air dry "Sea Bamboo" has a value of over £3 sterling, which the farmer in the coast districts can cart to his farm at a very small cost.

The "Sea Grass" and "Algae" have a value which also must appeal to the farmer, and if he would only collect the bones in his household, let his servant crush them in an ordinary iron mortar, and mix them with the sea-weeds, he would have with little outlay secured a very powerful manure which would greatly augment the returns of his lands.

UNIT OF RADIOACTIVITY.—The Commission appointed by the International Congress of Radiology, which was held at Brussels last September, has decided to call the quantity of emanation in equilibrium with a gramme of the element radium a *curie*, and to adopt an international radium standard, which is to be preserved at Paris.

INTERNATIONAL ASSOCIATION OF SEISMOLOGY. Delegates from twenty-three countries belonging to the International Association of Seismology will meet at Manchester during July under the presidency of Prof. A. Schuster, Ph.D., F.R.S., F.R.A.S. Dr. Schuster will be glad if anyone interested in the subject of seismology will communicate with him.

SCHOOL BUILDINGS AND SITES.

By Arthur Henry Reid, F.R.I.B.A., F.R.San.I.

In submitting this paper my object is to convince the lay mind that a well-established general knowledge of applied science is necessary to the selection of sites and to the designing of school buildings.

For some years there has been, I feel, a tendency on the part of Public Bodies to belittle the advice of scientists and professional men, with a corresponding tendency to discount their opinions, and, if possible, to act upon their own initiative. The excellent organization and administration of the Education Department has, of course, counteracted the tendency, and has doubtless so far educated the public mind as to prepare it for the guidance and advice of such bodies as the South African Association for the Advancement of Science.

In the hope of being useful to those who are interested in the promotion of educational building schemes and of securing a discussion that can only conduce to sound knowledge of the subject, I have ventured to submit this paper.

I will deal with the site first and then touch upon the buildings.

SITE.

A school building site should be high, dry and with adequate fall for the complete removal of surface water. Marshy land should be avoided, and if subsoil water exists, drains for the removal of the water should be constructed, or, better still, another site be selected. A damp subsoil causes many diseases, such as diphtheria, typhoid fever and rheumatism. Headaches and languor generally result in a school where a damp atmosphere is breathed, for it is only natural when the temperature of a schoolroom is raised that evaporation of moisture from the soil takes place as well as from the floors and walls, which would probably be damp from the same cause.

Should examination of a site show that portions are of "made" ground, trial holes should be sunk to ascertain that no animal or vegetable refuse has been buried there. On no account should a building be erected above "made" ground, for, putting aside the increased cost of foundations, the danger of gases and other emanations, especially in warm humid weather, are apparent.

Where possible a natural, hard, dry top soil with a gravel subsoil should be selected, or, as alternatives, sand or sandy clay. Pure clay retains moisture, is cold and affects the stability of buildings, as it shrinks in dry, hot weather, and expands when damp and cold, thus causing cracks in walls and in the surface of paved floors, etc.

A school site should be removed from traffic and noises of all kinds, as the former is dangerous to children when on their way to school, exposes them to dust, and the noise of traffic interferes with school work. The proximity of factories, tanyards, stables, cowhouses or other industrial buildings should be avoided, as the odours are often injurious to health and intercourse with the employés undesirable. A site should not be surrounded by buildings, as they interfere with the diffusion of light and air.

PLAYGROUNDS.

In arranging a school yard for playgrounds it should be nearly level and at least 50 square feet should be allowed to each scholar, or say $\frac{1}{4}$ acre to each 250 scholars *as a minimum*. Double that area is not too much.

If possible the shade afforded by trees should be secured, or as an alternative verandahs, sheds or other shady retreats should be provided as an escape from sun or rain. No buttresses or recesses to the walls abutting upon playgrounds are desirable. Playgrounds should be as free from dust as possible, and where turf is impossible the surface should be covered with clean, homogeneous gravel, laid to such falls as will ensure the rapid removal of surface water, with intercepting gutters to prevent a rush of water sufficient to wash away the gravel coating. A portion should be covered with asphalte, concrete or paving for drilling purposes.

When laying out playgrounds due attention should be given to aspect when placing the buildings, so that a maximum of protection from prevailing winds and sun is secured. Decency and convenience must also be studied in the location of latrines and refuse depositories. Separate playgrounds should be provided for boys, girls and infants, and, where possible, space should be provided for football, hockey, cricket, tennis and games.

All grounds should be neatly fenced with unclimable and safe material, a due regard being given to privacy where desirable. Shelters are always acceptable, and attention should be given to the safe removal of flood water without overflow or damage to adjoining properties, at the same time guarding against the escape of water from neighbouring properties upon the school site. In towns where drainage systems exist, due regard must be given to the falls of ground and drains to the public sewers.

The speedy conduct of rain water from the roofs, so that it does not run broadcast over the site, is an important matter.

Cycle sheds, tool sheds and such administrative adjuncts must not be forgotten, and where drinking fountains are provided they should be of a type not requiring the use of dangerous cups.

While recognising that artistic and pleasing architecture and internal adornment of school buildings is of an educational and moral value, I propose to confine my remarks more to the hygienic points to be observed in them, and only single-storied buildings will be dealt with.

BUILDINGS: ASPECT.

Too much care cannot be bestowed in deciding upon the aspect and axial arrangement of the classrooms. In this country a northern aspect for the windows is to be avoided on account of the extreme heat and long exposure to the sun, while a westerly outlook is undesirable for the same reason.

The longitudinal axis of a classroom should be as nearly south-west to north-east as possible, with the windows facing south-east, but due regard must be paid to altitude, climatic conditions, prevailing winds in summer and winter, and the local surroundings, peculiar to the locality of the proposed building.

There are, however, certain rules that apply to all cases, and to such I propose to give prominence.

BASEMENTS.

Where basements are needed, trial holes should be sunk to prove that the subsoil is not waterlogged or damp, for the expense of constructing damp-proof walls and floors will be a serious matter.

No basement or cellar should be entirely below the surface of ground, and the floor above it should leave at least 3 feet in height for the admission of natural light and air to all portions of it.

The floors should be of cement concrete, with asphalte finish, turned up the walls if necessary, and the walls should be of an impervious, non-absorbent material built in hydraulic cement with vertical and horizontal damp-proof courses or cavities, as circumstances may require. Ample and permanent ventilating flues, with gratings to exclude animals, insects or driving rain, should be formed through all walls above ground level, and some should be carried down, in the walls, to admit fresh air about 12 inches above the basement floor level.

The floors should have a regular fall to a "sump," into which water would flow in the process of washing, or in case of flooding from any unforeseen cause, such as leaky roofs, defective windows or open doors on the rainy side of the building.

ENTRANCES.

Entrances should be sufficient in number for each sex and for infants and be so placed as to separate one from the other. The infants' entrance should be in proximity to that for the girls. All should be roomy to avoid overcrowding on entry or release. Doors should open outwards and be of sufficient width for the safe and rapid discharge of scholars in case of fire or panic, while they should be so placed as to be sheltered from prevailing winds and driving rain.

Where necessary, wind screens should be provided to the exposed frontages, and where steps are required there should be a flat or landing outside the doorway. Scrapers and door mats should be provided, and racks with pans below them to receive wet umbrellas on occasions. Wells or sunk spaces for mats should be avoided to prevent accumulation of filth.

CLOAK ROOMS.

Cloak rooms should be placed conveniently close to the entrances, and on no account be a portion of the assembly hall or class rooms. Separate rooms should be provided for the sexes, and they should open off a corridor with wide archways instead of doors to prevent overcrowding around the entrance and to secure proper supervision and ventilation. Separate entrances for admission and exit are desirable to avoid confusion and secure speedy passage through. The windows should be of ample area, easily cleaned and so arranged that a constant supply of fresh air and through draught is secured and circulated around the clothing racks. Every precaution must be taken against the air of cloak rooms finding its way into the assembly hall or class rooms. Inlet and outlet ventilators, independent of the windows, should be provided to secure perfect ventilation when the school is closed and perhaps the windows are closed. Cloak rooms should be in a shady aspect and kept as cool as possible to prevent germ development; the floors and walls should be lined with impervious material that can be speedily washed and disinfected. All joints should be of hard and non-absorbent cement, perfectly smooth and flush with the face of wall lining, and all inside and outside angles of walls and the joint of walls with floors be rounded off to prevent any accumulation of dirt. Projecting skirtings or mouldings should be avoided for the same reason.

Drying closets for wet clothes and boots are not as a rule required in this country, but the provision of a small air-tight closet for the fumigation of garments or books by formaldehyde vapour would be a wise and inexpensive precaution, as epidemics and vermin are not unknown even in the better class of school. In many of the lower grade schools I submit that a bathroom or shower bath should be provided, as children from the poorer homes are often dirty, and for the sake of their cleaner fellows should have the means of cleansing themselves, which are often, I fear, not to be found at their homes. Each cloakroom should be fitted with clothes and hat racks of enamelled metal, with wire netting backs to secure a circulation of air. A space of 12in. should be allowed to each scholar, and each should have his or her own hat and clothes peg kept quite distinct, so as to prevent overlapping of the next section. At least 4 feet should be left clear between each range of racks and between the racks and seats that may be against the walls, but entirely moveable. Should lockers be favoured, they must be moveable to ensure periodical airing and cleansing.

LAVATORIES.

In connection with the cloak rooms, but distinct from them, ranges of lavatory basins, supported independently of the floors, and fitted with self-closing cocks, wastes and concealed supply pipes, should be provided, say one basin for every 12 or 15 pupils. The provision of towels, however, is a debateable matter.

BATHING TANK.

In many schools where water furrows skirt the sites a swimming or plunge bath, with running water passing through it, would be the means of providing beneficial exercise as well as cleansing.

SINKS.

Sinks should also be provided in convenient positions for washing ink pots and school utensils, and "hoppers" for the reception of dirty water used in washing the floors are advisable to prevent the foul water from being thrown upon the playground.

PRIVIES OR W.C.'S.

At least one privy or w.c. should be provided for each 12 to 15 pupils, and in designing them due regard should be given to the sex and age of the users, as well as to privacy, separation, and, where tubs are used, to the speedy, cleanly and complete removal of same.

Privies should never be nearer than 50 feet to any window or door of the building, should be placed in a shady position so that the prevailing summer winds do not blow from them to the school buildings. The necessity of covered ways from the school to the latrines depends upon circumstances, but on no account should the sides of such be entirely enclosed. Precautions are necessary to prevent children from gaining access to the cleaning space behind privy ranges and to so segregate the sexes by screens or other means that one cannot see the approach of the other. I propose to deal only with privies, presuming that water closets are out of the question.

The disposal of urine, in the case of boys, is always a troublesome matter, but from experience gained under varying circumstances I am disposed to favour the use of buckets, with moveable trays or strainers on top, which can be filled with sawdust, preferably that from pitch pine, as that seems to prevent speedy decomposition and to act as a deodorant. Say one urine tub to 20 boys should suffice and they should stand in enclosures shaded from the sun with hard, smooth and impervious finish to the floors and walls so arranged as to be easily flushed out with water-tight and exposed sumps, into which the foul water should run and be immediately removed, after receiving a liquid disinfectant.

Daily removals and cleansing of latrines should be systematically insisted upon, and the Principal should make it his duty to inspect the yards and latrines daily, for, if left to assistants or servants, it is never done. Each privy should be at least 6ft. 0in. by 3ft. 6in. by 9ft. 0in. high, with impervious, smooth and washable floors and walls. All seats and tubs should be easily removed, and the privies kept as cool as possible by having thick brick walls on the sunny sides and well-ventilated "pitched" roofs instead of the usual "lean-to" type. Ceilings should be of plaster and kept cool by a "brand zolder" or other material. Each

compartment should have cross ventilation by louvres at the ceiling level, and the doors should have a 4in. clear air space below and above them. Locks should not be permitted, as latches or bolts on the inside are sufficient. Light should be provided over the door, or in back wall as circumstances may require, and "hatches" should be placed below the seat to prevent draught from the cleaning area behind the range. Screens carried by brackets from the wall should be fixed between each pair of urine tubs to guard against indecency, and due regard to sex and age should be given in designing the type and height of seats to privies.

ASSEMBLY HALLS.

In buildings where assembly halls for scholars are desirable, at least 6 superficial feet of floor area per scholar should be allowed in this country in elementary, and 8 in secondary schools. At least one side of the hall should have low windows of sufficient area opening direct upon open ground, with ample clerestory windows in the opposite wall. They should be capable of being thrown entirely open, and therefore should be hung on centres. The old system of a central assembly hall is now so generally condemned, and is so unsuitable for this country, that I do not propose to deal seriously with its merits or faults. The open quadrangle with broad cloisters or covered stoeps for assembly purposes is the requirement for South Africa, and the subject is dealt with elsewhere in this paper.

CORRIDORS.

Connection class rooms should have at least one side with direct light, and, if possible, cross ventilation by windows or double doors on both sides. If used for drilling purposes the corridors should not be less than 13 feet wide to enable 2 boys to perform extended drill, side by side, without knocking the walls or one another's knuckles. No connecting corridor should be less than 8 feet wide, and no doors opening into them should be directly opposite other doors; none should be less than 10 feet high, and the floors and walls should be finished as the class rooms, due regard being paid to the matter of noise occasioned by the traffic during class changes. If deemed desirable, inspection hatches can be provided in the walls between corridors and class rooms.

CLASS ROOMS.

This opens up such an important subject that I have found it necessary to divide my remarks into sections, all of which following apply generally to class rooms:—

DIMENSIONS.

The size of class rooms must be governed to some extent by the lighting requirements, also by the seating arrangements, whether single or double desks, width of gangways and open area around the master's dais.

In the hotter centres of this country I submit that at least 12 superficial feet of floor area per scholar should be allowed for elementary schools and 16 feet for secondary establishments.

The number of scholars per room being fixed, the floor area is easily decided by calculation, but there still remains the relative length, breadth and height to be determined, and upon the scientific adjustment of these factors the effectiveness of the lighting and ventilation depends.

Now, assuming that a class room should be lighted on one side only, and that in this country it cannot be properly lighted if the opposite wall is more than 23 to 24 feet distant from the windows, it naturally follows that the width being thus fixed, the length is computed by that required to seat the number of scholars stipulated for. This number is, of course, governed by the limit of distance that the farthest scholar can be seated from the teacher, and as this may be placed at 24 to 25 feet, the length of room should not exceed, say, 30 feet. It must not be overlooked, however, that in this country of bright light and clear atmosphere the maximum or minimum width of a class room must to some extent be regulated by the aspect of the windows and the exposure of them to sun during school hours.

The height of a class room is an important factor in the lighting thereof, for if a room is, to meet certain requirements, of necessity more than 25 feet wide, the height of room must be increased to secure sufficient lighting area from the windows. As regards the acoustics and ventilation of a class room, it is generally admitted that any excess over 13 feet in height from floor to ceiling is a waste. Now, assuming that a class room is required to accommodate, say, 40 scholars, the floor area (allowing 16 square feet per scholar for a secondary school) would be $40 \times 16 =$ 640 superficial feet, and as the width is limited to say 24 feet, the length of room would be say 28 feet. Thus the cubic capacity allowed per scholar would be $\frac{24 \times 28 \times 13}{40}$ = say 218 cubic feet, which is about right, though I know more than that is laid down in some Departmental schedules as being necessary, and under certain climatic conditions the requirement is undoubtedly reasonable. On the other hand, in the cooler districts 180 cubic feet has been found ample.

So much, however, depends upon the natural ventilation of the rooms when windows are open and when, in bad weather, closed, that each case must be dealt with upon its own scientific basis.

LIGHTING.

It is hardly necessary to preface my remarks upon lighting by reminding my readers that a class room must be lighted from the left hand side of the scholars when seated, and that the windows must be equally distributed over the wall area, and not be irregularly spaced, as in the latter case the light would be unequally distributed over the room. It is also an acknowledged fact that the farther side of the window that is farthest from the teacher should be in a line with the backs of the last row of scholars. These are the bases upon which the lighting of a room is calculated.

Now the necessary area of glass in a sunny climate such as ours is a difficult problem to solve, and in solving it the aspect of the windows naturally has to be considered. I propose to assume that the longitudinal axis of a class room should be south-west to north-east, with windows facing south and east, and it seems reasonable to assume that as one-fifth of the floor area is considered right as the proportional area of glass to floor in Europe, that one-sixth on the shady and one-eighth to one-tenth on the sunny side should be ample here, presuming that no natural light is reduced by the use of shutters or blinds.

It must, however, be borne in mind that when a hot wind is blowing or the normal temperature is high, the larger the windows are the higher the temperature will be inside the building.

Anything more than the amount of glass required to provide effective light to a room in the winter season is objectionable, as the excess can only make the room unnecessarily hot in summer and cold in winter. The bottom of the glass in a class room window should not be more than 4ft. 6in. above the floor level, and the head of window should be, say, 1ft. 0in. below the ceiling. These two factors will decide the width of window openings and of the piers between them; the relative width of the latter should not exceed one-half that of the former, due regard being given to the presence of air inlet flues in the piers, should they be necessary. Care must be taken to ensure the thorough lighting of the master's dais, and it is well to keep the sills of the windows that flank his seat 12in. lower than the others, so that he can see what is going on outside. On no account should any window face the scholars when seated, but small clerestory windows with their sills high up above the heads of scholars are useful as ventilating agents in the wall opposite to that in which the windows are. The light from these can be reduced by glazing them with green cathedral glass or by having green glazed hoppers at their sills to intercept the rays of light. A white ceiling best diffuses light, and light grey or green colour to the walls is most comfortable.

Glare or glitter or reflected light from the walls or openings in a class room is most objectionable, and therefore highly glazed tile or brick dados are not to be recommended.

Artificial lighting needs no consideration here. No trees or adjoining buildings should be allowed to obstruct the light of class room windows. Small panes of glass in windows are objectionable as rendering the cleaning of the glass difficult, especially when the astragals are of wood. The practical requirement is that every scholar in a room when fully seated should be able to read the smallest standard regulation type of printing at a distance of say 14 inches from his eye.

VENTILATION.

In this country I am convinced that natural cross-current ventilation by means of scientifically disposed windows is the most reliable, but exhaust tubes of a sectional area of at least 30 superficial inches per scholar should be provided in proper positions at

the ceiling level to pass through the roof and be fitted with effective "registers" or valves at the ceiling level, as well as exhaust heads above roof level to induce draught and prevent down draught. Inlet air flues in the piers between windows weaken them considerably, but they are useful when, on account of high winds or dust storms, the windows cannot be opened. If scientifically distributed so as to catch all air currents, and if properly fitted with louvred inlet gratings, draught deflectors, dust interceptors and common sense valves that cannot be tampered with, they are quite effective.

The sectional clear way area of the flues and appurtenances should be at least 4 inches per scholar.

It must be borne in mind that an ill-ventilated room predisposes scholars to many epidemic diseases, and in any case the organisms become depressed and the dangers of all diseases become intensified.

Every class room should be cleared and every door and window simultaneously opened at most after 1½ hours' occupation by its full complement of scholars.

HEATING.

In some parts of South Africa, especially at the greater altitudes, it has been found necessary to provide fireplaces in classrooms, but the subject is not of sufficient importance to enlarge upon here. In very exposed positions it would probably be necessary to heat all corridors as well as the rooms, and in such cases a mechanical circulating system of low pressure hot water pipes, with radiators at the fresh air inlets, would probably be the most efficient and economical. On no account, however, should the temperature, at any time, be allowed to exceed, say, 60° Fahr.

WATER SUPPLY.

The greatest care should be taken in the selection of a source of water supply, as the danger of contamination of wells and open water furrows is great. Where possible, a supply under constant pressure from municipal water mains should be insisted upon. Tanks are always a danger from neglect of cleansing and possible pollution by mosquitoes, birds, mice, etc., that get access to the water when the manholes or overflows are left exposed. If exposed to the sun the water in tanks becomes hot and quite unfit for human consumption.

FLOORS.

Class-room floors should be of such material as can be easily cleansed, with as few and as close fitting joints as possible, to prevent the harbouring and incubation of disease germs. The dry sweeping of floors is worse than useless, as the process merely whirls the dust into the air to alight again upon the floor, furniture and books. I need hardly remind my readers that it is just the inhalation of this dust, which is often more or less germ-laden, that accounts for much of the pulmonary tuberculosis that is too common in schools generally to-day.

All floors should be sprayed with a liquid disinfectant before being swept, and all joinery, furniture and wall and ceiling faces should be dusted, and, where possible, rubbed down with damp cloths. Moulded skirtings or any projections that will harbour dust and cannot be cleaned by a simple and speedy process should be avoided. All spaces between floors and the natural ground must be adequately ventilated to prevent dry rot and the accumulation of foul air. In the case of double-storied buildings the upper floor should be rendered dust-proof, and have water and dust-proof joints to avoid the passage of foul matter to the space below the boarding.

CEILINGS.

Ceilings should be of material that can be easily cleaned from below. Where hard finished plaster is impracticable, asbestos slabs or compo-boarding will probably be the most sanitary, safe and economical material, having fewer joints and being more fire-resisting than matched boarding. "Brand zolder," sawdust and lime or other sound-proof material should be laid upon the upper side of ceilings to deaden the sound of rain upon the roof and to keep the ceiling cool. Access to each roof should be provided by manholes in the ceilings. Ceilings should be distempered, or, better still, oil painted, white, for the diffusion of light, for the detection of dirt and for the ready removal of fly soils without damage to the ceiling material.

ROOFS.

Roofs should be covered with material that is a non-conductor of heat and as noiseless as possible. Sheet iron, though serviceable, when far removed from saline sea air, and cheap, is both hot and noisy when rain or hail is falling. The various forms of ruberoid sheeting, when laid on boarding, are better than iron, but tiles are the most serviceable and in the long run the most economical material to adopt. All roof spaces should be ventilated and cooled by the admission of cool air at the eaves level, and its removal through "louvres" at the ridge or other convenient spot. Hips and valleys should be avoided as tending to leakage and repairs.

DOORS.

Each class room should have one doorway only opening up a corridor or cloister, and not into another class room or assembly hall, if such can be avoided. No door should be immediately opposite another in a corridor, and under certain circumstances a glass panel for inspection purposes is desirable. All doors should open into a room, at the same end as the master's dais, and on his left hand side when seated. They should be hung to open towards the scholars, and no mouldings or harbours for dust should be permitted on doors, linings or architraves. Door latches should be substantial and simple and fixed at convenient height from the floor for children's use.

WINDOWS.

In this country I am inclined to favour the ordinary double hung sash windows with the frames fixed just clear of the outside plaster, so that shades or shutters can be hung without the use of double jointed hinges. The lower portion of the windows, at sill level, should be fitted with an adjustable glazed "hopper," the front of which could be fixed at any angle from 5 degrees to 20 degrees, according to circumstances, thus admitting fresh air without causing a draught upon the heads of scholars. A transom and fanlight should also be provided above the head of top sash, the latter bottom hung to fall inwards with glazed "cheeks" to check side draughts and exclude driving rain. The inner jambs should be splayed and plastered without linings or architraves. The heads of windows should be as near the ceiling as possible or even above the ceiling, if necessary, to afford sufficient light. No mouldings or harbours for dust and dirt should be upon sashes or frames, and the glass should be in as large panes as is practicable to facilitate complete cleansing, not forgetting, of course, the extra cost of reinstating large panes when broken, All fasteners and fittings should be of the simplest type but of good quality, easy of lubrication, and in all cases worked by cords or gear from the floor level.

Kindergarten and manual instruction rooms should have windows on at least two sides, to avoid unnecessary movement and straining of the eyes, as well as to provide perfect cross ventilation (see "Lighting").

SEATING CAPACITY.

Not more than 40 scholars should be accommodated in one class room for the higher standards or 50 in those for the lower standards, and in no case should less than 24 be allotted to one room.

TEACHERS' ROOMS.

In large schools the head master and head mistress should each have a retiring room or office, which should be in such a position as to command the entrance to the school, and, where many assistant teachers are employed, a "common room" should be provided for their use. A small lavatory, with sink and changing room, is always convenient, especially for female teachers, and it should be within easy access of the head teachers' rooms. These rooms should be well lighted and ventilated.

STORE ROOMS.

Store rooms for books, stationery and school material should adjoin the teachers' rooms.

LIBRARY.

Where necessary, the room allotted as a library should be in a quiet, secluded position, and where literature is circulated among the scholars, it is a wise precaution to have a small disinfecting closet in connection with it.

GYMNASTIC SPACE.

Where possible, room should be provided for gymnastic exercises. The best shape for such a room is an oblong, the light being admitted on the longer side or both sides. Cross ventilation is most desirable in this department. Due provison must be made for hanging and moveable apparatus and for storing it when not in use. The doors must be wide enough for all apparatus to pass through easily. In this country, when the quadrangular type of school plan can be adopted, it is well to use the central space of the quadrangle for physical exercises and training. Under certain circumstances the assembly hall can be fitted and used as a gymnasium, but it is seldom satisfactory. Children under 14 years of age should not be permitted to use fixed gymnastic apparatus (see " Corridors ").

STAIRCASES.

Where the buildings are arranged on more than one floor ample provison must be made for the safe and speedy discharge of scholars in case of fire or panic. At least two staircases are necessary in large establishments, and these should be at the extremities of the building. They should be of incombustible material throughout, and at least 4 feet wide, without winding steps. No flight should have more than 12 to 15 steps, and the treads should be 12in. wide by 6in. high, it being presumed that infants would naturally be located on the ground floor. In all cases solid brick walls should be on both sides of all staircases, and at least one wall for light and ventilation should be an external one. If less than 150 scholars are located on the upper floor, probably one staircase would suffice, if placed in a safe position, and in any case strong handrails should be provided at a suitable height on both sides of the steps to assist crippled or nervous children. The treads of stairs should be of a non-slippery material without nosings or projections of any kind. Should there be any screens or doorways to the staircases, the doors should open outwards from the stair flight.

BLACKBOARDS.

Blackboards to class rooms and elsewhere should be of such material as to favour the use of dry dusters. Plate glass ground rough on the writing surface and enamelled on the back to a dark olive green is the best and, in the long run, the most economical. If plaster mural boards are used with composition applied as a writing surface, care should be taken that nothing of a poisonous nature is used. No mouldings, grooves or other harbours for dust or filth should be allowed around the boards.

CUPBOARDS AND SHELVING.

Cupboards and shelving should all be easily removable in sections, so that during recess they can be taken away and scrubbed, disinfected and aired before replacement. No permanent lodgment for dust against the walls should be possible either inside

or outside. They should be provided in every available recess for the storage of books, loose maps, etc.

WALL FINISHINGS.

The inside wall plaster should be painted to a light subdued tint of grey with a permanent washable waterproof material in preference to distemper. The latter is easily soiled, is absorbent, and needs complete removal before a fresh coat can be applied, which is a dirty and expensive job, whereby the floors suffer considerably.

DADOS.

Dados should be of specially hard and impermeable material, and where pressed asbestos slabs, dull glazed tiles or earthenware cannot be adopted, good smooth cement plaster should be applied, and, after being painted, a finish of dull " flat " varnish should be applied. Dados with highly glazed and reflective surfaces are very objectionable in class rooms, but not so in corridors, halls or cloak rooms.

SCIENCE CLASS ROOMS AND LABORATORIES.

Science class rooms and laboratories open up such a tremendous field that I cannot find time to touch upon them on this occasion, but hope to do so on a future one.

NOVA LACERTAE.—A new red star, of 7.5 magnitude (visual), was discovered by the Rev. T. E. Espin at Towlaw, Durham, on the 30th December. The star is within the southern border of the Milky Way, and may be regarded as the apex of an approximately equilateral triangle, whereof Alpha and Beta Lacertae form the basal angles. The spectrum of the nova shows bright lines, and the lines of hydrogen and helium have been specially noted. A bright line in the red, apparently the C line of hydrogen, was observed by Mr. Espin, and there were two other conspicuous lines, the stronger of which seemed to be F, while there was also a yellow line, probably D_3 Three bands were observed between F and D, and a strong band on the more refrangible side of F, beyond which a bright band was visible. At Cambridge Observatory seven or eight bright lines have been noticed in the nova's spectrum. The star is now evidently diminishing in brightness, for reference to photographic plates taken a month earlier show it as of the fifth magnitude. Prof. Max Wolf announces in *Astronomische Nachrichten* that a 13th magnitude star occupied the present position of the nova on some plates taken at the Königstuhl Observatory a few years ago, but photographs taken at Harvard in 1887 show no trace of the new star.

A NEW CAPE THERMAL CHALYBEATE SPRING.

By John George Rose, F.C.S.

In 1906 a syndicate was formed for the purpose of boring for oil in the neighbourhood of Port Elizabeth. A borehole 404 feet deep was put down; but, as no definite information was obtained thereby, a company with a capital of £13,000 was floated, and in April, 1908, boring operations were begun in the Zwartkops Valley with a most modern outfit on the jumper principle capable of boring to 5,000 feet if necessary. The drill was of the type known on the Boryslaw oil fields as the Canadian Galician, iron rods 38 feet in length being used in its working. The initial diameter of the bore was 18 inches, decreasing gradually to 6 inches as the depth increased beyond 3,000 feet. It was lined throughout with artesian casing, and so true was the bore that at a depth of 3,400 feet the entire casing, weighing some 60 tons, was lifted and turned daily. Red clays, shales and sandstones were passed through up to 3,234 feet, when a very hard, coarse, yellow sandstone was entered, which gave great trouble in drilling, getting harder and harder as the depth increased. On the 29th May, 1909, a spring of hot water was struck at a depth of 3,400 feet. Its temperature was 108°F., and the water flowed freely from the borehole at the rate of 35,000 gallons per diem. At the request of the company, the author visited the spring on the 15th July, 1909, for the purpose of taking samples for analysis. The bore had then reached a depth of 3,450 feet. A temperature of 125°F. was found at the surface, the daily yield being 130,000 gallons. The bottom temperature had been taken the day previously by Mr. G. W. Smith, of Port Elizabeth, who found it to be 4°F. greater than at the surface, viz., 129°F. Analysis showed the water to be that of a thermal chalybeate spring, and the company were advised accordingly. It was also suggested to them that, as the prospects of finding oil were not very encouraging, boring should be stopped, and the medicinal properties of the spring exploited. Boring was, however, continued until November, 1909, when a depth slightly in excess of 3,460 feet had been reached, and progress had become extremely slow owing to the increasing hardness of the rock.

On the 2nd of that month the author paid his third visit to the spring, and found that the temperature had risen to 128.5°F and the yield increased to 250,000 gallons per diem.

The chemical composition of the water was as follows:—

Common Salt	25.71	grains per gallon.
Sulphate of Magnesia ...	3.07	,, ,, ,,
Carbonate of Magnesia...	2.10	,, ,, ,,
Carbonate of Lime... ...	2.06	,, ,, ,,
Bicarbonate of Iron ...	1.66	,, ,, ,,
Alumina	.02	,, ,, ,,
Silica	1.60	,, ,, ,,

In common with most deep-seated springs, that at Zwartkops contains gases in solution. These were collected by Mr. J. Muller, Government Analyst at Grahamstown, and sent by the Company to Sir James Dewar for analysis. He found the gas to consist of :—

Carbon Dioxide	3.43%
Oxygen	11.54%
Nitrogen, Hydrogen, Helium, and Neon...	85.03%

In 1,000,000 parts of gas from Zwartkops the Hydrogen, Helium and Neon are 741 parts, while at King's Well, Bath, England, they form 1,516 parts of the gas in solution.

The Iron content of the spring has been subject to considerable variation, the author having found quantities varying from 0.8 to 1.0 grain per gallon of Ferrous Carbonate, while Sir Wm. Crookes obtained as much as 3.78 of Ferrous Carbonate from a sample drawn in December, 1909. The amount seems now to remain constant at about 1.7 grains per gallon. At times the odour of sulphuretted Hydrogen has been noticed, but it is doubtful whether this gas is present in the Thermal chalybeate water. Other springs had been tapped in the course of the work, some of which reach the surface *outside* the casing, and it seems most probable that the gas in question comes from one of these.

Bath rooms have been erected at the spring, and many patients have taken the waters, apparently with very beneficial results. As a table water it is very palatable when charged with carbonic dioxide, this gas also completely preventing the precipitation of the Iron which otherwise takes place on exposure to air. The Eastern Province is to be congratulated on the possession of so valuable a spring, and it is to be hoped that the owners will soon afford facilities for those who cannot afford the long journey to, and luxury of, the famous Caledon Spring to utilize the very similar water which has now been discovered in their midst.

COMETARY ORBITS.—Mr. R. T. A. Innes contributes to the December issue of the *Monthly Notices of the Royal Astronomical Society* a paper on the mean or perihelion distances of comets. The author summarises his discussion of the subject thus :—

> "The elliptic equation between the mean motion and the semi-axis major does not hold in the solar system. In the cases of minor planets and with comets with large distances, the error in the mean distance (or perihelion distance of parabolic orbit) deduced from the elliptic formula will affect the 5th significant figure. Unless the Gaussian constant is suitably modified, it will be impossible to get a complete reconciliation between observation and theory."

Mr. Innes ascribes the inconclusive results of so many investigations of comets' orbits to the neglect to apply to the equation of planetary elliptic motion the correction rendered necessary when there are more than two bodies concerned, and hence in the case of comets. This neglect makes the velocity depend on one conic section and the radius vector on another. The consequence is erroneous geocentric co-ordinates, and accordingly an impracticable ephemeris.

SOME NOTES ON TREATMENT OF SANDS FOR STOPE FILLING.

By Thomas Donaldson.

The past year has witnessed many new developments in connection with the handling and treatment of banket ore, but the so-called "stope filling" is perhaps the most noteworthy of all. By "stope filling" is meant the filling up of those crevices in the bowels of the earth from which the ore containing gold has been extracted. This is not the place to describe the principle of mining, but it is perfectly evident even to the non-technical person that unless this ore is taken out with great care, *i.e.,* unless strong enough pillars or supports are left for the superincumbent rock, there will be a risk of subsidence. That such incidents take place very frequently is part proof at any rate that mining has not been too carefully carried out in the past. Perhaps this is not to be wondered at, for it is most unnatural to leave in position masses of ore which are known to be rich in gold, and which would help to swell dividends. Be this as it may, the Rand has had many warnings during the past few years that something drastic had to be done to prevent bad becoming worse. Only the other day, a little to one side of an important street, a cart and two mules disappeared completely owing to a subsidence, and only by the luckiest chance did the driver escape. On the East Rand a few years ago, a whole dwelling disappeared, and only by the luckiest chance again, was the loss of life not greater. The so-called "earth tremor" which is reported every other day, and the recent air blast of the Cinderella Deep, which was attended by great loss of life, have shown, if that were necessary, that something has to be done quickly. Fortunately our mining engineers are alive to the problem, and a start has been made. Of course, it must be confessed that mining, no matter how carefully it is carried out, will always lead to movement of masses of rock, for anything which disturbs the internal structure of the earth's crust is bound to set up new stresses and strains, and this has been experienced all over the world. Some years ago, in the coal mining districts of Silesia, occurrences not unlike those of the Witwatersrand were taking place, and the authorities in charge then hit on the plan of filling up the disused workings with the waste material which had been taken out, sluicing them down by suitable mechanical and hydraulic arrangements. So far as the information which we have goes, the procedure has proved a success, and a similar plan has recently been adopted for some of the collieries in Scotland. The advantages claimed for the process are, firstly, that it will minimise the chance of rock movement, and, through consolidation of the deposited mass, will allow of the "drawing" of the supporting pillars, thus extending the profitable life of the mine, and secondly—and this is of particular interest to the Witwatersrand—that it will simplify

the problem of ventilation. This latter is so self-evident as to require no elaboration. From æsthetic and the health point of view, however, the question appeals probably more to the Rand than to any other mining district in the world. Everyone admits that the mine dumps are an eyesore, and they cannot be beautified by any known means, for nothing will grow on them. Then their presence aggravates the dust nuisance, and may even, as some assert, lead to municipal silicosis. Be that as it may, all resident about Johannesburg look forward with undisguised pleasure to the day when dumps shall be no more; when they will return whence they came, after having served their undeniably useful purpose. From what has just been said it will be surmised that the intention is to sluice these dumps back into the mine again, and this is really what is now being done on a small scale, but the problem is far from being a simple one. True, the Australians have been filling up old worked-out places in their gold mines for years, and although their difficulties are not the same in all respects as those existing on the Witwatersrand, it is encouraging to know that they have apparently overcome them; but time alone can tell this. As far as the Rand is concerned, the procedure adopted is comparatively simple, and can be easily described. The tailings (sands, not slimes) are dumped or sluiced into a large chamber, where they are mixed with the proper proportion of water. A further mixing is ensured during their passing through a launder provided with a series of "baffle plates." Ultimately the pulp is lowered into the workings, either through a pipe column, which generally goes down the shaft, or through a borehole specially prepared for the purpose, and by means of suitable branches is distributed to the various stopes which have to be filled in. The sides and bottoms of these are bratticed off at the lowest levels, leaving a semi-firm deposit not unlike the sand left on the beach after the tide has receded. So far as experience goes this has never hardened to any great extent, and is hardly likely to do so, although there is hope of assistance in this direction by addition of one or more of the various bodies suggested, possessing cohesive or setting properties. There is also no experience to show how this mass would behave in the event of a mass of rock coming down on the top of it. The use of a borehole instead of a pipe column, as a channel for introduction of the pulp into the mine, means a large saving on the wear of pipes, which are acted upon mechanically by the sands, and chemically by the acids formed from oxidation of the pyrites. With this latter aspect we shall deal presently.

The method just outlined is the one most commonly in use on the Rand. Although it demands very little surface plant, it is obvious that much water has to be run into the mine with the sands, and a large portion of this water has to be pumped back to the surface. Another method has been introduced recently which, besides other advantages, is said to have the effect of greatly reducing the quantity of water to be dealt with. Further reference will be made to it, when dealing with the question of the destruction of cyanide.

Great as the mechanical difficulties are in connection with the handling of the pulp, they are being gradually overcome, and the main interest is certainly chemical. All the banket ores contain pyrites, some greater and others lesser amounts, but all contain some. Now in the hot humid atmosphere of the mine the pyrites oxidises, producing sulphuric acid, so all mine water is acid. This factor of itself leads to considerable expenditure on renewals to pipes and pumps. Then the tailings, as has already been said, also contain pyrites, and oxidise, so that accumulated tailings are very strongly acid. For this reason, in the early experiments, the wear and tear of the pipes was terrible. This has been overcome by the addition of alkali in the form of lime, but the amount required makes the process somewhat costly. Current tailings or sands, *i.e.*, the product as it comes from the cyanide leaching vats, is always slightly alkaline, due to the addition of lime at a certain stage of the metallurgical process; consequently, if they are used, the difficulty of acid is overcome, but another one is substituted through the presence of cyanide—for they always contain a certain amount of this bodv. One can easily realise what might happen if acid mine water were to come into contact with tailings containing fixed cyanide. Given enough of both, every person in the mine would be poisoned by prussic acid. The problem to be solved on the Rand at the moment is, how to fix this cyanide so as to render it innocuous, and the problem is far from being a simple one. There are then two sets of raw materials available for stope filling; firstly, accumulated sands containing no cyanide worth speaking of, but a great deal of acid; and secondly, current sands containing no acid but a good deal of cyanide.

A good argument in favour of the use of current sands is that they can be taken from the treatment tanks direct to the chamber in which the mixing with water is carried out, whereas the accumulated sands have, at considerable cost, to be shovelled from the dump into trucks, and conveyed sometimes over considerable distances to the mixing chamber.

Taking all the points mentioned into consideration, one is inclined to think that, although both classes of sands are in use to-day for stope filling, as the practice develops, current sands will almost exclusively be used, provided a cheap and suitable means of destroying the cyanide in them can be found. Mention has already been made of the two methods of stope filling in use on the Rand to-day, and in view of what has just been said, it will not be out of place briefly to compare these methods as to their suitability for dealing with current sands.

The first method referred to was described by Mr. E. Pam at the June meeting of the Chemical, Metallurgical and Mining Society of South Africa. By it, the pulp passes direct from the mixing chamber into the mine, so that only a few minutes elapse between the time of mixing with water and the moment when the sands reach their final resting place in the stope. There can be no objection to this so long as accumulated sands free from cyanide are used, but if current sands, involving the use of

"cyanicides" were substituted, in view of the dangers which would arise from the introduction of free cyanide into the mine, the "cyanicide" employed would require to have the power to destroy the cyanide almost instantly; and further, in order to avoid high costs, it would require either to do its work in comparatively slight excess or have the virtue of extreme cheapness.

The other method of dealing with the mixture of sands and water was described by Mr. O. P. Powell at the August meeting of the Society already referred to. It is of special interest because current sands involving the use of "cyanicides" are daily being dealt with by it. The main point of difference between it and the first method, lies in the use of "Caldecott" de-watering cones. Before passing to the borehole the pulp is pumped into these cones. There the greater proportion of the water is removed and only a thick pulp passes from the bottom of the cones into the borehole. The value of this arrangement in saving the pumping of so much water from the mine has already been mentioned, but the point of most importance to us at the moment is that the sands take something like three to four hours to pass through the cones, so that the "cyanicide" in use, which, it should be said, is added at the mixing chamber, has a considerable time to get in its work before the sands actually pass into the mine. Further, the bulk of the excess water separated off in the cones is led back to the mixing chamber and used over again, thereby effecting economy of the "cyanicide" by utilising any excess of that body present in the water. These less exacting conditions allow of more scope in the selection of a "cyanicide," and at the same time the danger of evolution of prussic acid in the mine is reduced. Of course, this arrangement calls for considerable initial outlay for plant where some thousands of tons of sands have to be dealt with daily, but as the cones do their work without the help of mechanical power, and require very little attention, the running costs are low.

I propose now to review shortly the various means proposed for the destruction of cyanide in current sands. Various well-known chemicals, nearly all oxidising agents, have been proposed for this purpose. In June, 1910, Dr. Moir and Mr. J. Gray read a paper before the Chemical, Metallurgical and Mining Society giving results of their experiments with ferrous sulphate. Under suitable conditions, in contact with cyanide, this body forms ferrocyanide, which is harmless. The principal conclusions arrived at by those gentlemen were that (1) in no case was complete conversion of the cyanide effected, although under favourable conditions the quantity left was negligible; (2) rise of temperature about 20°C. was harmful to the reaction; (3) results were entirely independent of dilution; (4) the reaction was as complete in 5 or 10 seconds as after long standing.

At the same meeting Mr. H. A. White gave details of laboratory trials with alkaline permanganates, aldehydes, ketones and alkaline picrates. Of these bodies Mr. White seemed to prefer permanganate. For it he claimed (1) complete destruction of

the cyanide present, the first stage in the reaction being formation of potassium cyanate, which afterwards breaks up into carbon dioxide, ammonia and nitrogen; (2) that only slight excess of permanganate is required; (3) that the cost for permanganate works out at between 6d. and 9d. per ton of sands. The reaction evidently takes about four hours to complete. At the July meeting of the same Society Mr. White gave some results of experiments with bleaching powder as a "cyanicide." He stated that, as with permanganate, in alkaline solution potassium cyanate is formed, and this afterwards breaks up, forming ammonia, nitrogen and carbonate of potash. Mr. White explained that unless alkaline solutions are used there is a danger of cyanogen chloride being formed, a body which is nearly as poisonous as cyanide itself. The advantage of bleaching powder over permanganate is greater cheapness. It is interesting to note that both permanganate and bleaching powder have been used, on the large scale, in conjunction with the method of sand filling referred to as described by Mr. Powell, and both are said to have given satisfactory results.

The writer has been concerned in the making of some experiments to find out the action of a solution of polysulphides of calcium on cyanide in current sands. This solution is prepared by boiling sulphur and slaked lime together in water. Small scale experiments indicate that, given time, comparatively slight excess of this body in presence of alkali can completely convert the cyanide into the harmless and stable sulphocyanide, and with considerable excess of the polysulphides the cyanide can be completely converted in about five minutes. The experiments were made with sands containing a relatively high percentage of cyanide. The serious results which might arise from the presence of prussic acid in the atmosphere of a mine have already been referred to. There is little doubt, however, of a tendency in certain quarters to exaggerate the danger, and it is quite probable that in decently ventilated places a little prussic acid might be allowed to pass into the atmosphere without risk. On this question hangs the closely related one of whether it is necessary to destroy all cyanide present in the sands before they enter the mine, and if not, what percentage may be left in them. This is a difficult question and one to which no student of the subject in this country has risked a definite answer. Some experiments on this point, carried out on right lines, would be of considerable interest even if no very definite results were to be obtained.

In conclusion, I beg to express the hope that these notes will help to give an idea of what has been done in this country in regard to this highly important but comparatively recent development of the Mining Industry, and at the same time convey some notion of the difficulties which have been, and have still to be overcome.

The papers which have been read on the subject and the discussions which have taken place at the meetings of the Chemical, Metallurgical and Mining Society, besides having a decided influence on the progress already made

reveal a desire on the part of those most interested in the directing of stope filling operations to interchange ideas and compare results. It seems to the writer that this spirit of co-operation would most fittingly find complete expression in the formation of a commission composed of engineers, metallurgists and chemists in touch with the subject. The commission, besides collecting information, could have powers to arrange and carry on experiments for the purpose of properly comparing existing proposals and methods and trying new ones. Surely this would be the quickest and in the long run the cheapest way of arriving at the best working methods.

ELECTRIC HOISTS ON THE TRANSVAAL MINES.

The *Electrician* of January 6 contains a short description of electrically driven hoisting and winding plant recently installed at the Rand Collieries, near Johannesburg. At one of the Colliery shafts two hoists have been fitted, one capable of lifting three tons and the other six tons of rock. The conical drums, from 10 to $17\frac{1}{2}$ feet diameter, are coupled to direct-current separately excited motors, working on the Ward-Leonard system. It is estimated that one shilling per ton will be saved on the working costs by the use of electrical winding. The power is supplied, at 10,000 volts, from the Victoria Falls Power Co., and is converted at a transformer house to 6,000 volts. The six ton hoist is at present the largest on the Rand. Elsewhere on the Johannesburg mines much electrification is being carried on, mainly by German firms. The Ward-Leonard system is principally used for hoisting work, and the induction motor is supplied with high tension current direct, and fitted with rheostatic control.

THE EARTH'S REPULSIVE FORCE.—Prof. C. D. Perrine, of the Córdoba University, Argentine Republic, communicates to the *Monthly Notices of the Royal Astronomical Society* a short note on photographic observations of Halley's comet during its recent apparition, in the course of which he remarks: "I notice the suggestion of Innes that the Earth may have the power of repelling cometary tail-matter in a similar way to the Sun. It seems to me doubtful if this is the case. If this force is in reality light pressure, as seems very probable, the small intensity of the sunlight reflected by the Earth could hardly overbalance its gravitational force. If the force of repulsion is electric or of some other nature, then the case is otherwise.

THE BORDERLAND OF SCHOOL AND COLLEGE.

By C. D. Hope, M.A.

Few would be found so rash as to maintain that the borderland of school and college had ever been clearly defined in South Africa. In fact the proposition might very well be extended to older countries; for English universities have not yet acted fully on the advice of Matthew Arnold, who told them that they should definitely abandon every kind of study which could be successfully pursued in the senior forms of public schools. It is, therefore, in no way discreditable for a new country to admit that this realm of educational activity is still debateable ground. Perhaps, indeed, the expression "debateable ground" is misleading. There is no real debate between the schoolmaster and the college professor as to the standard of attainments which should be exacted from the student on passing from the lower stage to the higher; both are agreed that the requirements should be more exacting and the age should be more advanced than at present. But both schoolmaster and college professor have to deal with a public opinion utterly unenlightened upon this subject and entirely convinced that its retrogressive ideas are founded upon the most complete knowledge and experience.

It cannot be claimed on either side that the boundary has ever been adjusted in accordance with fixed and immutable principles. The history of most colleges throughout the world has begun with a period in which school work had to be undertaken, for the simple reason that schools were not yet sufficiently advanced to perform their proper functions. For instance the early statutes of one of the Oxford colleges reveal a time when students, who arose at five in the morning and retired to rest at eight o'clock at night, were liable, if their conduct was unsatisfactory, to be chastised by the Dean with a birch rod. Some of us can remember a period when colleges in the Cape Colony contained many matriculation classes, of which the senior class consisted of candidates for the examination of the current year, while the junior classes were composed of students whose chief duty was to swell the numbers of their college and so to augment the claim of the institution for the Government grant in aid of higher education.

Under these primitive conditions there was no clear distinction possible between a schoolboy and an undergraduate except such as could be enforced by the test of examinations. The clever boy passed his matriculation earlier, entered the senior classes where more competent teaching was given and delighted his parents by reaching the goal of a B.A. degree, while his more backward contemporaries were still struggling with the routine of school lessons. Who then could maintain that an age limit was desirable? The work of school and university was extended along one uniform

road whose milestones were recognised from the " School Elementary " to the B.A. ; and the imposition of any restrictions would merely have been the holding back of clever boys from their natural course of advancement.

The first step towards reform came when the educational authorities limited the grant for higher education and prevented it from being granted for students below the first matriculation class. Later on the essential step was reached of treating all work below the matriculation as school work. The senior classes of the colleges were divided from the junior, and became at last University Colleges for matriculated students. For the first time in their history it was possible for them to confine their efforts to the work of higher education. From this time, then, we must date the birth of true University Colleges and of actual High Schools, which—whatever their names may be—do not aspire to send in pupils for a B.A. degree, though the " Intermediate " has remained a matter of conflicting claims.

This parting of High School from University College took place at different dates in various parts of South Africa. Little had been accomplished before 1895, and we may probably place the average date of the change several years later. When we remember, therefore, that it is less than 15 years since the B.A. student was merely the senior school-fellow of youngsters who were struggling with the " three R.'s," there is no possible reproach to the teachers of South Africa in the statement that the boundary line has not yet been established between School and College work.

During the same years the development of primary and secondary schools has begun to reveal the fact that school work is something more than the path from the kindergarten to the bachelor's degree. The value of many subjects is at last being estimated with reference to the production of a man, even when they show no tendency to stimulate the growth of a precocious graduate. Drawing, music and geography can do little towards the production of Masters of Arts; while the woodwork of boys or the needlework and cookery of girls will be found to have as little connection with purely academic distinction.

After all it is a man that we want to produce, fitted for success in colonial life; and not a young Mandarin, trained to pass examinations and gain employment as a Civil Servant. From this point of view we must emphasise and not minimise those sides of school training which have least bearing upon examination success or upon the production of precocious undergraduates. One criticism which the schoolmaster most frequently hears from his candid friends is a complaint of the poor elocution of his pupils. " Why do you not teach your boys to speak? Not one in a hundred is fit to read out a legal notice in a law court, and none of them will ever be sucessful orators." This is most deplorably true. All we can say is that we do our best with the juniors, but that elder boys are too busy with examinations ahead of them to spare time for anything which does not pay in marks.

Cannot something be done by the public of South Africa to make clear speaking a valued accomplishment? Language in this country is becoming far too much a matter for the eye only. The literary studies in the University Colleges must surely suffer from the fact that the ear and tongue of the student have never been trained. Not only is this the case; but the merely intellectual study of printed literature is singularly barren of reward, for it entirely fails to earn due public recognition. There have been graduates of the Cape whose intellectual capacity stood very high, but whose elocution was such that they would have passed for uneducated men among strangers either in London or Amsterdam. In contrast to them we have known ladies whose one accomplishment was the power to read aloud with clearness and precision, but the exercise of this acquirement enabled them to hold their own among people of literary and cultivated taste.

Much has been done by the Taal Bond to promote a taste for literary Dutch; but the enforcement of a standard of pronunciation has not yet been attempted, perhaps it may be the next step. Cannot something of the kind be done for English? The music examinations offer an example which might be imitated. Why should not peripatetic examiners issue a certificate for good reading, clear recitation and correct conversational language? At present a girl spends perhaps ten or twelve hours a week in learning to play Beethoven and Chopin; but if she retains the pronunciation of the house-maid, her accomplishments will fail to do her credit.

American schools advertise "elocution" as one of their principal subjects, and all French teachers are severely drilled in pronunciation and voice-production, in which they have to satisfy examiners, sometimes appointed from the Conservatoire, where actors graduate for the stage. Here, then, we have the example of the two most democratic countries in the world. This surely is sufficient answer to those who regard recitation as a fashionable fad and who sneer at anything that may be called an attempt to impose on an independent public the stilted affectations of Mayfair. It may be admitted at once that considerable latitude and variety may be allowed. Cultivated men from London, Dublin and Boston may easily be distinguished by the variety of their intonation; but all of them are capable of reading Milton or Shakespeare with dignity and taste. So it may be with the cultivated South African of the future, if some attempt is made to ensure dignified utterance.

The curriculum of our schools is too narrow in other respects. Boys whose future will depend upon a ready knowledge of practical methods of calculation require further mathematical training than they at present obtain; while as many as possible should acquire the power to read either French or German. To take the first of these subjects: a somewhat rash scheme has originated in England for bringing Trigonometry and the use of logarithms within the scope of Seventh Standard pupils. However this may turn out, there is no question that these subjects are thoroughly suitable for boys in the Fourth and Fifth Forms of High Schools.

But not only have South African schools excluded these branches of mathematics, they have—until quite recently—cut down Algebra and Geometry to absurdly small proportions. In fact the last decade of last century saw the matriculation mathematics hardly more than a glorified edition of primary school work.

How then is the scope of school work affected by the boundary line which separates it from University studies? The authorities of the University may turn round and ask us why we do not go forward with all the work we claim to undertake: drawing, wood-work, elocution, an additional modern language and practical mathematics. Our answer is this:—"We cannot do so until you establish a minimum age for matriculation." As long as the parents of would-be mandarins see the very material advantages which are gained by the boy who matriculates at fourteen, they will lead the way in clamouring that their boys shall be pushed forward; and the whole body of parents and pupils will continue to despise every branch of education which does not give palpable assistance to the passing of public examinations at the earliest imaginable age.

Boys matriculate at fourteen—there are probably several such cases every year—thirteen is not unknown. Yet most colleges at Oxford prefer their freshmen to be nineteen and refuse to take them under eighteen. The Scotch universities have arrived at much the same opinion; one, at least, of the South African University Colleges has enforced a minimum age; and it only remains for the others to follow suit or for the University to take action as a body. In the meantime their decision may be accelerated by the assurance that the consummation is as devoutly to be wished in the interest of the schools as in that of the University.

One other matter concerns the affairs of the Borderland. Contrary to British and American precedent, the South African Colleges have unanimously accepted the rule of senates and have rejected the rule of Principals. This is eminently a matter of which they are themselves the best judges; but one result has come about which has not yet been publicly criticised. The Colleges are ruled by groups of specialists, and there is no official adviser to consider the new student and his interests apart from the conflicting claims of the various subjects in the curriculum. A definite example may be the best explanation of this deficiency. A shy boy of very good ability recently entered one of the colleges with the idea in his mind that he would study biology and qualify himself for a scientific profession connected with agriculture—either as a veterinary surgeon or as a bacteriologist. This boy's actual attainments had, so far, been mainly mathematical, and he was, accordingly, appropriated by the Professor of Physics. A year later he told his old schoolmaster that his plans had been changed. He was working for a degree in mathematics and physics and could see no prospect of future employment except as an electrical engineer; but he was still convinced that natural science and agricultural work would have given him far greater satisfaction.

THE CAPE KLIP-FISHES.

By Prof. John Dow Fisher Gilchrist, M.A., D.Sc., Ph.D., F.L.S., and William Wardlaw Thompson, F.Z.S.

The Blenniidae, to which the "Klip-fish" group belongs, are a widely distributed family of fishes occurring most abundantly in tropical and temperate seas, though some forms inhabit the colder waters; they are mostly coast fishes, but some lead a pelagic life hiding under floating seaweed, others have become specialized in fresh-water lakes. Their size as a rule is small, ranging between the extremes of the six-foot Sea-wolf (*Anarrhicus lupus*), esteemed as food by the natives of Iceland and Greenland, to the tiny Blenny of one or two inches in length.

The genus *Clinus*, or Klip-fish, appears to have its headquarters in the Southern Hemisphere, and the many species that occur on our coasts are very characteristic of South African shore life over a fairly wide area extending from the tidal margin as far out as rocky banks on the 20-fathoms line. The several species are admirably adapted to the diversified environments of the littoral; some frequent open pools, others twist their eel-like bodies in and out of crevices of the rocks, others live amongst the sea-weed and all seem to be more or less protected or concealed by their similarity to the surroundings, whether rock, weed or sand.

At least 22 species of *Clinus* are known in South African waters, as contrasted with 16 species of all the other genera of Blenniidae represented, and it is a peculiarity of their distribution that they appear far more numerous on the West Coast, from Walfish Bay round the Cape Peninsula, occurring again at intervals on the South and East Coasts as far as East London, where an allied genus, *Cristiceps*, is also found; on the Natal coast only one species, *C. laurentii*, has so far been noted, the place of *Clinus* being taken by two other genera of the Blenniidae —*Salarias* and *Blennius*. The genus *Clinus* therefore seems to be an essentially cold water fish, and of the 22 species recorded at least 20 are found in Cape Peninsula waters.

The smallest species known is *C. dorsalis*, which does not seem to exceed 3 inches in length; the largest is *C. superciliosus*, which sometimes reaches 18 inches. A natural division of the various species may be made into those in which the anterior dorsal spines form a distinct but not separated crest and those without crest; these again may be sub-divided according to the presence or otherwise of tentacles over the orbits.

Generically, we may define the body as more or less elongate and tapering, in some species produced into a cylindrical, eel-like form; the dorsal fin, composed of many spines and one or more soft rays, is continuous and extends from behind the nape almost to the tail, in some cases being connected with the latter by a membrane. In one species, *C. superciliosus*, the length of the crest formed by the first three spines of the dorsal fin has a distinct sexual significance, being decidedly larger in the male.

The scales of the body are usually minute and deeply embedded in the skin; in fact Kolbe (circa 1705) records that the Hottentots would not eat Klip-fish because of the absence of scales—an error easy to be understood considering the difficulty of detecting them with the naked eye in the common Klip-fish; *C. biporosus*, a comparatively rare species, is the only one that is really scaleless. In two others, *C. graminis* and *C. brevicratus*, on the contrary, the scales are distinct and comparatively large. All the species being carnivorous have their jaws provided with sharp-pointed teeth which in some appear as a single series on each jaw, in others as an outer row with a band or cluster of smaller teeth behind; usually there is a curved band of small teeth on the vomer. The eyes are somewhat specialized, being so placed in the head that they can readily see upwards, and, particularly in some species, can be rotated independently, like a chameleon's; when both eyes are directed to an object close at hand this doubtless enables the fish to judge the distance accurately. In many species there is a fleshy stalk with a fringe of slender filaments above each orbit, the use of which is not definitely known, but it would appear to act as a screen to hide the restless eye of the lurking fish from its anticipated prey, possibly it may shield the eye in other ways.

The colouring of the Klip-fish group presents an astonishing range of hues—often subdued or uniform in tone as in the "Slangetje" (*C. anguillaris*), but for the most part brilliant and diverse; from the startling and bizarre combinations of blotches and bands often met with in the "Bull-klip" (*C. taurus*) to the wonderful blendings of vivid brown, red, green, yellow and blue tints, with transverse bands, reticulations, streaks, and spots found in such species as *C. superciliosus, C. ornatus, C. pavo, C. venustris* and others. Numbers of the same species living in the same area are frequently quite different in colour and markings, and most of the species possess the power of changing or adapting their colour to new surroundings, in addition to their intensified hues during the mating season or under the influence of excitement.

The brilliancy of hue appears to be, to a great extent, associated with sexual attraction, but the combinations and shades of colour also bear a marked relation to the environment of rock, sand, weed, or coral and seem largely mimetic and protective; in the latter sense covering not only the escape from detection by an enemy but also prevention from detection by the prey. As an instance of this we may notice the effect of the colouring displayed by the common Klip-fish (*C. superciliosus*). At certain seasons of the year the young of this species are found in considerable numbers in the rock-pools on the shore-line, having apparently come in from deeper water, as many other young fish do, probably as a means of escaping their natural enemies the larger fish. In the shallow pools, however, other though perhaps less dangerous enemies are to be met with. These small fish have a keen vision; on suddenly looking over a rock-pool we can see a sudden darting of numerous little forms to places of safety, and a moment afterwards the pool seems to be quite devoid of fish

life. On closer examination the little fish can generally be made out, usually of a greenish hue with dark spots which break the contour of the body so that it is frequently almost impossible of detection until they are again disturbed and reveal their position by movement. The greenish hue is seen only in those in pools with green sea-weed (*Ulva*) and in the younger forms this colour is very pronounced. Observations made in the Aquarium illustrate the advantage to the fish of similarity with its surroundings as regards concealment from its prey. Occasionally small mullet ("Harders"), which at times are found in abundance in the rock-pools, are kept in the same tank as the Klip-fish; they swim about in groups, generally near the surface but sometimes lower down, and the Klip-fish may occasionally be seen watching them intently with body motionless and tail slightly bent preparatory to a sudden spring, the only movement being the rotating eye that follows every motion of the prey, and is apparently somewhat concealed from observation from above by the orbital fringe or tentacle. When the incautious victims approach near enough the Klip-fish launches itself suddenly at them, and usually manages to secure one.

The diversity of colour is most marked in the adults, and it is of course difficult to determine whether or not the brilliant shades of colour afford an effective protection or concealment as in the case of the young; but many of the fish found in the "sea-bamboo" areas are of uniform tint—a rich bronze-green, or crimson, red, yellow, etc., all of which hues seem to harmonize with the various shades of alcyonaria, sea-weed, etc. In some localities the sea bottom seems to be clothed with extensive growths of the "red coral" or "zee-tak" (*Gorgonia flammea*) so frequently thrown up on the shore. On several occasions large pieces of this coral were secured for the Aquarium, and it was noticed that a Klip-fish of a bright uniform red colour was very fond of resting lengthways along the red branches, and, although a fairly large specimen, was not easy to detect even at close quarters.

A noticeable instance of resemblance to surroundings, not only in colour, but in general form and habits also, is afforded by one species of Klip-fish, *C. fucorum,* to which we shall refer more fully when describing the fish.

In the mating season—about midsummer—the demeanour of the Klip-fish seems to undergo a change; the males become fierce and aggressive and their diversified colours are more conspicuously displayed; the females also seem to assume brighter hues.

Fierce contests frequently take place between the males. Their method of fighting is peculiar; the fish circle round each other in a threatening manner but make no attack until a certain position is taken up by each. This may be described as resembling an open letter. The fish lie not directly facing each other but with their heads alongside of each other, the body being gently curved and the tail well bent to the side opposite the antagonist so that by its sudden flexure the heads may be brought violently in contact; the advantage apparently lies with the fish that can

execute this movement most rapidly and accurately, so that it can seize the jaw or cheek of its opponent. The fighting attitude is characteristic and is almost as expressive as that of the higher animals; the gill-covers are distended displaying the ocellated spots of the operculum, the crest and fins expanded to their utmost and the eyes have an expressive gleam which one would hardly expect to see in a fish. The threatening attitude generally lasts from a quarter to half a minute, after which the attack is made so rapidly that the details of what took place cannot be followed, the scars left on the side of the head or jaws being the only evidence that any damage had been done; the attack seems to be simultaneous, but a fraction of a second would of course be of the greatest importance at such close quarters (about a quarter of an inch). The final settlement was seldom seen, but it was generally decisive, the defeated fish being sometimes so exhausted after the fight that it fell an easy prey to some of the large starfish in the tank.

On two occasions combats between Klip-fish of another species were witnessed, and are of interest as showing a totally different mode of procedure. The species in question (*C. cottoides*) is also one of the commonest forms and very abundant in shallow pools; it is smaller than *C. superciliosus* and of a different form, the head being relatively broader, and it is not characterised by the same brilliancy of colour, being generally a dull gray with a conspicuous large spot on the gill-cover. The species does not exhibit the same sexual phenomena as in *C. superciliosus*, and the cause of the quarrel in the particular case noted was unknown; two of these fish were seen making violent movements in a cloud of sand in the corner of the tank and, on closer examination, they were found to be in fierce combat. As in the previous case mentioned, the attack was not made indiscriminately, but only after a certain position had been taken up. Here the combatants were directly face to face, the mouth of each was dilated to its utmost extent, and the gill-covers projected almost at right angles to the head, bringing into view the large black opercular spots which, viewed from in front, looked like a pair of eyes on a very large head ludicrously out of proportion to the small (about 8 cm.) and rather feeble body, but doubtless sufficiently terrifying when viewed from in front by any animal of the same size. The tail was sharply flexed so that the body could be suddenly projected forwards. Thus prepared, the combatants rushed at each other, the main object apparently being to open the mouth wide enough to seize the upper and lower jaw of the antagonist; after the first rush the fight became for a moment indiscriminate, any part being seized when a chance was given; this lasted only for a few seconds, when the fight became orderly as before. After a few rounds of this nature one of the combatants showed less interest in the proceedings and quietly backed away, still, however, in a threatening attitude.

Opportunities are occasionally afforded in the Aquarium tanks for observing, to a limited extent, the earlier stages in the life of our marine fauna. On more than one occasion a small group of transparent little fish made their appearance in one of the

tanks in which Klip-fish were kept, and recently a chance was afforded of unmistakably noting their origin, as a specimen of *C. superciliosus* gave birth to 24 young ones in one of the smaller tanks in which there were no other fish. These young Klip-fish were almost transparent and swam freely about near the surface below the inlet pipe, their rapid movements in the water making them difficult to keep under observation. At this stage, not only were they protected by the absence of colour, as in the case of most young fish, but they had well-developed air bladders which enabled them to swim freely near the surface. The adults of all the Klip-fish group, and of the Blenny family generally, are devoid of an air bladder and cannot readily swim about for any prolonged time without occasionally resting on the ground or on rock, weed, etc., for which their neutral fins and sometimes some at least of the rays of the anal fin are specially modified.

Economically the Cape Klip-fish have long been well-known; more than 200 years ago Kolbe recorded how eagerly the burghers of Cape Town bought them from the Hottentot fishermen, and Astly, Barrow, le Vaillant and others have drawn attention to the merits of "Klepvis." We have no knowledge of the particular species they referred to, for the name "Klip-fish" is applied generally to all the members of the *Clinidae;* it is more especially understood, however, as belonging to a group of about four species, of which the best-known and most widely diffused is *C. superciliosus.* In the Cape Peninsula this species is in the best condition and most abundant during the winter months, May to August, but all the year round the rockpools of the shoreline seem to hold their quota—one of the most prolific spots being the "Kommetje."

C. superciliosus seems to be the only species of the Clinidae in which the height of the dorsal crest has any sexual significance. In the male the height is about twice as great as in the female and equals three-fourths to four-fifths the length of the head; the crest is formed by the irregular lengthening of the first three spines, and though quite distinct is not separated from the rest of the fin, the connecting membrane being attached fairly low down near the base of the fourth spine; when not in use it lies back along the fin. In the female the crest, besides being lower—not exceeding half the length of the head—is more rounded in shape and there is generally a dark oval spot on the membrane connecting the second and third spines. The colouring of this species is on the whole brilliant and diversified, ranging from sober browns to vivid tints of red, green, orange and purple, with kaleidoscopic combinations of spots, blotches, bands and lines; as a rule there are reticulated markings on the head and cheeks and more or less well-defined irregular bands, about six in number, cross the body and extend on to the dorsal fin.

Further observations may show the disability of classifying some forms now included under *C. superciliosus* under one or more sub-species or varieties, especially in view of the occurrence of many strongly-marked specimens, sexually mature but of diminutive size and slightly different in shape.

One variety has already been formed—*C. superciliosus*, var: *arborescens*—which is met with in the same localities and is very similar in shape and size. The distinguishing characteristics are the comparative lowness of the dorsal crest, which is about the same height as in the female of *C. superciliosus*, and the fact that it does not differ in the sexes; further, the orbital tentacles show a slight but constant divergence, being usually of a light yellowish colour and rounded and fringed or branched at the sides in distinction to the flattened and divided stalk of a dark blackish-brown or liver colour met with in *C. superciliosus*. The combinations and richness of the colouring are not so pronounced in this sub-species, nor are there any reticulated markings on the head.

A species closely resembling the foregoing, but of a coarser build when mature, and with perpendicular corrugated markings on the lips, is *C. robustus*. The anterior spines of the dorsal fin are not so high, but are strong and erect, and there is a deep notch between the third and fourth spines. This fish possesses in a very marked degree the power of assimilating its appearance to its environment, and has been observed in the Aquarium to put aside its usual colour scheme of dark brown or bronze, green, etc., with dark transverse bands and to assume a dingy white hue corresponding to the sand on which it rested.

Another of the group is a handsomely marked fish called *C. ornatus*, generally caught on weed-grown banks off-shore. The spines of the dorsal fin are long, slender and flexible and the connecting membranes between them delicate and easily broken; the crest formed by the three anterior spines is as high as that of *C. superciliosus*, but is more oblong in shape as the spines are more equal in length. This fish well deserves its name of "*ornatus*" from its very vivid colouring; orange and red markings and patches predominate and the membranes between the rays of the pectoral and caudal fins are usually transparent and crossed with lines of orange or brown dots.

Mingling with *C. superciliosus* and its sub-species, especially in localities where sand intermixes with rock and weed, is the "Bull-klip" (*C. taurus*). Its broad bull-like head and comparatively large mouth, with the heavily fringed tentacles like eyebrows over the strong orbital ridges, give it rather a truculent aspect; in the Aquarium, however, it is of an easy disposition, generally lying quietly about in nooks and crevices, but it can give a shrewd nip when incautiously handled, and possibly in its natural state it may derive some protective benefit from its fierce appearance. The spines of the dorsal fin are short and strong, especially the first three, which are separated from the rest by a membranous notch. The colouring of this fish is generally strongly marked and deep in tone, sometimes very handsome but often gaudy and bizarre; in some localities it is a uniform shade of dull crimson or brick-red, bronze or light green, etc., in others three or four irregular dark bands cross a ground of dark yellow ochre or reddish brown, bronze or light green, etc.; the whole body frequently splashed or blotched with irregular large white or red patches, often irregular pinkish patches occur

on the head and shoulders, and these get very vivid when the fish is excited or angry; the fins may be tipped with orange or red, and irregular yellow and black markings occur on the throat and shoulders. The Bull-klip is very widely distributed, but only two or three seem to live in any one neighbourhood; it also possesses in a very high degree the power of changing its hues. It is not considered an edible Klip-fish, for even when skinned and the ugly blotchy head cut off, which is said to be the only way of preparing the fish for eating, the flesh is insipid.

A fish of a very different appearance is the "Slangetje" or Snake Klip-fish (*C. anguillaris*); it gets its name from its cylindrical eel-like body, and prefers the more or less dark, secluded holes and crevices of rock-pools. The dorsal fin is low and has no crest; both it and the anal fin reach entirely to the tail, to which they are joined by membranes which form a deep notch between the respective fins. The scales are minute and deeply embedded in the skin; the colouring is generally uniform, in various shades of brown, yellow, dull crimson, etc., often mottled with darker spots or blotches and occasionally with traces of cross bands of darker hue.

A local variety which has been found in Simons Bay very closely resembles the "Slangetje" in general characteristics, and has been named *C. striatus;* the colouring is in longitudinal stripes of alternate pinkish-brown and white from eye to tail, with a white band from eye to dorsal fin and a brown band from eye to snout.

One of the quaintest looking of the Clinidae is *C. fucorum,* a fish that, as already mentioned, is a striking illustration of the way in which not only the colour of some Klip-fish is adapted for concealment but their general habit and form are apparently modified to increase the disguise. In this species the profile of the head descends abruptly to the short, pug-nosed snout, which is a most characteristic feature, the upper lip being turned up and slightly projecting, and the mouth, with its single row of closely set teeth, being very oblique when closed. The well-developed dorsal fin begins a little behind the eyes, the first four or five spines forming a rounded crest; usually the remaining spines, by alternately lengthening and shortening in groups, give the fin an undulating appearance, but the height and extent of the undulations vary greatly in different individuals. The body, which is somewhat flattened or compressed, is about the same depth for two-thirds of its length, when it narrows to a comparatively long and slender peduncle, the tail itself being broad and rounded. The colouring of this fish is generally uniform in shade—dark yellow, yellowish brown, bronze green, etc.—sometimes with the fins and body speckled with dark spots, which may form bands across the body; the vertical fins are frequently tipped with orange. There are some peculiar features about the colouring of *C. fucorum.* In many specimens there are wedge-shaped patches quite devoid of pigment on the vertical fins, sometimes instead of being transparent they are of a very pale yellow; the general habit of the fish, in the Aquarium at least, is to recline partly on

its side almost motionless and in this position it closely resembles a detached frond of sea-weed, the transparent or yellowish markings appearing like decayed portions of the weed and the broad tail slightly curling up on its slender stalk lends force to the deception. A very striking mark—an almost circular patch of white, like burnished silver—occurs in the males, but is either altogether absent or very small in the females; it is situated about the middle of the body just behind the pectoral fin, by a movement of which it can be concealed or exposed; its *raison d'être* is unknown, but it may have some sexual significance. This fish seems rather sluggish in disposition; in the Aquarium when it did swim it was with slow and rather clumsy undulations of the whole body.

An easily recognizable species of Clinus is a bearded Klip-fish (*C. capensis*), which has eight filaments or barbels in a cluster on the chin and three on the slightly concave snout; the body is long and slender and the dorsal fin reaches to the root of the tail. In colour the fish is generally of a marbled brown or yellow or green, frequently with a row of dark blotches along the base of the dorsal fin and with irregular cross bars or blotches on the body, which is often speckled with white or other shades; usually there is a dark spot enclosed in an irregular white or red border or ring behind the head.

A very common species in the Cape Peninsula is *C. cottoides*, the adult form of which often closely resembles immature specimens of the Bull-klip (*C. taurus*). It does not seem to exceed 5 or 6 inches in length; the head is rounded, with a transverse depression behind the orbits. The eyes seem specially well adapted for turning in all directions so as to command a wide range of vision, and above each there is a bunch of five or six filaments on a broad base; the dorsal fin is low, with moderately strong spines but without any anterior crest. The colouring has a wide range of hues, but is generally one of the numerous shades of brown or green with a yellowish or greyish flush on the body and mottled with brown or yellow or speckled with white; there is usually a row of irregular dark spots or blotches along the base of the dorsal fin and a dark irregularly shaped spot on the gill-cover (operculum).

Another denizen of the rock-pools on the foreshore is *C. acuminatus*, a well-shaped but rather shy little fish, with a sub-conical snout and having a short tentacle with from three to five filaments on the end of it over each eye. The dorsal fin is comparatively low anteriorly, gradually increasing in height until the softrayed rayed portion reaches about twice the length of the first spine; the erect, moderate strong spines have their points exposed and generally with a short lobe branching off. The usual colouring is green of various shades, grey, yellowish or reddish brown; it is speckled with minute white spots, and there are from four to six irregular dark transverse bands on the body and often irregular clusters of white specks along the base of the dorsal fin.

A species less frequently met with is the "Grass Klip-fish" (*C. graminis*), which is occasionally to be found in weedy tidal

pools, especially those in which the green "sea grass" occurs; it rarely exceeds 6 to 7 inches in length. The contour of the body is more oval than in other species, and the scales are very distinct, rather oblong in shape and readily discernible to the naked eye; the head and snout are somewhat pointed, the mouth small, and there are no tentacles over the eyes. The first three spines of the dorsal, whilst not forming a crest, are erect, strong, a little higher than the succeeding ones and further apart individually, and from the fourth spine generally of a bronze or light green; it is met with in various shades of brown, and one specimen procured was of a deep maroon colour; a row of irregular spots occurs below the dorsal fin and sometimes below the medium line also, or there may be longitudinal bands with white specks here and there, or a row of small white spots.

The "Mouse Klip-fish" (*C. mus*) is a pretty little fish, 4 to 5 inches long, occasionally to be found in weed-grown stretches on the tidal margin, and may readily be identified by the long slender stalk or peduncle of the tail and the transparent membrane between each group of two or three spines in the dorsal fin; the nearly straight upper profile of the snout, with its slightly *retroussé* upper lip and the beady eye are not unlike that of a mouse. The crest formed by the first three spines of the dorsal fin seems at first sight to be quite separate from the succeeding spines, as the connecting membrane is transparent; the body is compressed and deep in proportion to its length. The colouring is very pleasing, generally of a uniform shade of crimson, green, yellow or brown; there may be a row of dark spots below the dorsal fin, or wavy lines of light yellow from head to caudal peduncle, or the body may be crossed by wavy single or double bands of chocolate brown, etc.

Another rather uncommon species, found in the same localities with the preceding, and about the same size, but of more slender make, is *C. pavo*. Its body is deepest at the shoulder, the head is long and vertically compressed, and the small mouth has protruding lips with a small flap on the chin. There are many more spines in the dorsal fin than in *C. mus;* the crest is low and the three soft rays of the fin are higher than the spines, the last ray being a little apart from the others and connected with them and with the peduncle of the caudal by transparent membranes. The fish gets its name from the row of dark, eye-like spots, like those on a peacock feather, at the base of the dorsal fin in the type specimens; in some cases, however, these spots only appear as faint dark patches. The body is often uniform in colour—shades of dark or purple brown, pale lake, flesh colour, etc.—and may have wavy bands of silvery white from snout to tail, or dark cross bands from the dorsal fin alternating with similar bands from the anal fin to above the lateral line.

Amongst the rocks on the fore-shore at Fish Hoek, near Kalk Bay, a beautiful little Klip-fish, *C. venustris,* is found; it is a shapely fish, apparently not exceeding 5 or 6 inches in length, the upper jaw seems very protractible and there is a membranous

expansion on the lip. There is no dorsal crest; the first two spines, which are weak, are close together, the first or sometimes both of them being the shortest in the fin; the connecting membranes of the soft rays are transparent. The colour scheme is rich and pleasingly blended; the olive-green, brown, or reddish ground being prettily variegated with markings of red, white, yellow and bright blue—the last named shade seems to be a speciality of this species, as it is a colour not hitherto noticed in others of the Clinidae. This little fish often has bright orange blotches on the body, or longitudinal bands of colour.

In the small, weedy, sun-heated pools of the St. James and Kalk Bay littoral a diminutive species, *C. dorsalis,* may often be obtained at low-water, seemingly quite indifferent to the comparatively high temperature. It is characterised by a sharp pointed head, a long slender body of the same depth for the greater part of its length, and a low dorsal fin extending to the base of the caudal and formed of numerous spines and only one soft ray. The uniform ground colour of green, yellow, brown, etc., in various shades, is often variegated with streaks or dots darker in hue. In some specimens there is a white streak from the snout passing upwards between the eyes to the origin of the dorsal fin, an oval black patch over the opercular openings with dark streaks radiating from the eyes and a row of black spots on the body along the base of the dorsal fin.

Another species, *C. biporosus,* is not often met with. It is an eel-like fish closely resembling the "Slangetje" (*C. anguillaris*); it is, however, without scales and gets its name from the double row of pores on the body, one on each side of the lateral line, ending in a single pore between the last ray of the dorsal and renal fins. The anterior spines of the dorsal are lower and not as strong as the remainder, which gradually lengthen until the height of the last spine equals half the length of the head. The colour is a uniform deep crimson, yellowish brown, etc.

Another less common species is *C. brachycephalus,* which has a short, blunt head, and the profile from snout to nape well rounded. There are no tentacles over the orbits, but there is a well-developed one, divided and fringed, over each anterior nostril. The first three spines of the dorsal fin are a little removed from the fourth, to which they are joined by a transparent membrane; the second spine is closer to the first than to the third; a deep notch is formed between the spinous and soft-rayed portions of the fin by the shortening of the last three spines. A distinctive mark is an eye-like spot, generally green in the centre, with a red border, which occurs on the base of the pectoral fin. The colour of this fish is mottled orange, or red, olive green, brown, etc.; there is often a band of white along the sides from the preoperculum to the posterior third of the body, with white spots above and below and at intervals on the dorsal fin; the pectoral, ventral and anal fins are strikingly marked with brilliant patches and spots of red, and the anal has white patches on its margin. There is a row of pores along each side of the curved portion of the lateral line.

Only one specimen has been procured of *C. latipinnis,* a fish that has the soft-rayed portion of the dorsal fin markedly higher than the spinous. The profile of the head is rounded, with a slight depression between the orbits, which have their upper margin swollen and with a short, thick, fleshy tentacle slightly flattened at the end, branched and with a broad fringe or row of cirri; the posterior nostrils are very prominent as open tubes and the anterior have a plain tentacle above each. The tubes of the lateral line (66) are well marked. The colour is brownish, with minute specks on the body and faint transverse bands; the pectoral and caudal fins are marked with brown dots which form transverse bars.

We have also had to describe another small Klip-fish, *C. brevicristatus,* from a single specimen, and it may be noted that this species seems closely to approach the genus *Cristiceps* owing to the membrane of the crest of the dorsal fin being attached so low down on the base of the fourth spine as to give the appearance of a separate crest; it is not separate, however, and the fish has therefore been classified under *Clinus.* The head is short and the snout blunt; the eyes are placed high in the head and slightly directed upwards, there is a shallow transverse depression behind them and a well-developed tentacle, formed by a broad flat stalk with nine cirri at the end, rises above each orbit; a similar tentacle with three or four cirri occurs at each anterior nostril. The height of the dorsal crest, of which the first two spines are longest and equal, is one-third the length of the head, the succeeding spines are low anteriorly but lengthen gradually to the middle of the fin; the last spine, however, is longer than those of the crest and the soft rays of the fin are still higher. In the specimen procured there is a deep notch between the 18th and nineteenth spines, but this may be due to an injury during an earlier stage. The scales are distinct and comparatively large, and there is a series of enlarged scales on the curve of the lateral line. In the specimen there are about seven dark chocolate brown irregular bands across the body and dorsal and anal fins, and between them irregular brick red bands from the base of the dorsal but not reaching the abdomen; a longitudinal series of irregular white patches appears below the lateral line, from pectorals to base of caudal and an irregular white band from inferior margin of eye to border of opercle, with a white patch on the throat below the opercle, another on the brown base of the pectoral and one on base of caudal; the soft dorsal was semi-transparent for about two-thirds its extent; the anal greenish yellow between the dark bands; ventrals the same shade with dark spots; pectoral and caudal fins semi-transparent, light greenish-yellow and with rows of dark spots along the rays; the upper part of the head was black.

We have not been able to procure a specimen of *C. heterodon,* recorded by Cuvier and Valenciennes. The spines of the dorsal are stated to be of uniform height, the soft rays a little higher; the colour is said to be brown, except the belly, which is reddish, and the extremities of the anal rays, which are whitish.

THE TREATMENT OF JUVENILE OFFENDERS.

By James Muirhead Potter Muirhead, F.S.S., F.R.S.E.

Every child born in a country should be an asset to it; if for any reason it does not become so, it is the duty of the State to take such steps as will as far as possible make it fulfil this its proper and reasonable function. In this country we have fortunately not yet any permanent pauper class such as older countries have; indeed, it is difficult to imagine a time when there will be any excuse for the existence of such a class unless it springs from crime, that most fruitful mother of pauperism; but in the past we have been and still are making criminals by wrong methods of procedure, failing to recognise that prevention is better than cure; it is quite impossible in a paper of the duration of this one to deal with the whole vast but fascinating subject of criminology; but I wish to point out how child criminals are treated here and in other countries, the systems adopted for their regeneration and how we can learn to take the necessary steps to make the child an asset and not a liability to the State. In Great Britain, children under 12 may under the Summary Jurisdiction Act by consent of their parents be tried summarily, as may those between 12 and 16 for certain offences. Under 7, in Great Britain and South Africa, New York, Russia and Portugal, a child cannot be a criminal; in France and Belgium 8, Italy and Spain 9, Norway, Greece, Austria, Denmark and Holland 10, Germany 12, Switzerland 14, Sweden and Finland 16.

In Great Britain, till 1838, children of 7 years of age and over were regularly committed to prison for petty offences, and lads of 10 and over to hulks and convict ships, but in that year the first State attempt was made to differentiate between the treatment of adult and juvenile offenders, to-day few children under 16 are sent to gaol, as civilisation has altered the national view of dealing with young delinquents, though it is still a national blot that there are no preventive measures for boys over 16; they must go to gaol if found guilty, and the permanent criminal ranks are enormously increased by this disgraceful condition of affairs. A boy of 15 found guilty of an offence punishable by imprisonment may be sent to a Reformatory School, till he is 19, but should he have "turned" 16 to gaol he must go, as the Reformatory Schools are only for children found guilty between the ages of 12 and 16; if he is over 14 it must be a first offence, however; Industrial Schools are for children under 14, mostly first offenders, and for those under 12 whose parents cannot control them or who are beggars. This system is a vast improvement on the awful days previous to 1838, and five years after the system was established juvenile prisoners had diminished by 50 per cent., but it still leaves much to be desired.

In France the excellent and obviously reasonable custom prevails of separating juvenile from adult prisoners during trial, and while under arrest, a feature I will refer to later when dealing

with our own Cape antiquated and utterly wrong system. Yet the French system otherwise also leaves much to be desired; children under 16 who acted without discernment may be either acquitted or returned to their parents, but if found guilty of acting "with knowledge," they must go to gaol for one-third to one-half of their sentence before being sent to a penitentiary, and the gaols are rarely cellular, so that the juvenile criminal gets his criminality confirmed by mixing with old offenders. France, however, started reform work earlier than England, and as far back as 1850 had five agricultural homes for juvenile offenders "without discernment"; there are also at present three reformatories for boys under 12 run entirely and successfully by Sisterhoods. There is also one very French penitentiary for girls where the State is making the interesting experiment of compulsory abolition of all religious instruction.

In Germany, children from 12 to 18 found guilty "without discernment," are usually acquitted, though they may be sent to reformatories or boarded out; even if found guilty "with knowledge," the punishments are usually very light indeed, still there are over 400 reformatories in Germany and the juvenile criminal is becoming a growing and increasing danger.

In Austria, children under 15 found guilty of an offence are usually sent to reformatories, where they are taught trades and discharged when 20 years of age; it is noticeable that Austria pays particular attention to the moral and religious training of reformatory inmates. In Holland, the system of with or without discernment is acted on and juvenile criminals after sentence are kept separate from adults, unfortunately those awaiting trial are not, which probably partly accounts for the abnormal growth of juvenile criminals of late years.

It is impossible to refer to the United States as a whole, for each State has its own laws and it would take up too much space to refer to them all at length, I will therefore deal only with New York as a fair specimen. A child under 14 is deemed incapable of crime unless the jury find "proof of capacity" where what would be felony in an adult is regarded as a misdemeanour and he is sent to a reformatory, the utmost care is taken that nowhere and under no circumstances can he mix with adult criminals, cases involving the trial of children are even heard quite apart from other cases and often under different surroundings. Even proved vicious boys of 7 to 16 are sent to a farm run entirely by the Brotherhood of St. Christopher and the results are wonderful, over 90 per cent. becoming good citizens; they are all taught trades after the system of our own Salesian Institute, and get to love their work. There is probably no town in the world where more is done for the prevention of crime on proper lines than in New York, aye and for the prevention of sin among children, and nowhere have the convictions so marvellously decreased, a clear proof, if proof were needed, of the value to the State of humane and sensible treatment.

Turning to a British country, in Canada all children under 16 are tried separately and without publicity, and previous to trial

are carefully kept apart from criminals or adults awaiting trial. Every town has a Children's Aid Society, the officers of which can arrest without warrant boys under 14 and girls under 16, if found neglected, sleeping out, begging, etc.; the Judge frequently appoints the society legal guardians of such juveniles, and they are boarded out till 18 years of age. Great care is taken in dealing with actual juvenile criminals, and the "public good" is always considered; they can be bound to responsible tradesmen till 21 years of age, or sent to Industrial Schools or Reformatories according to the special circumstances governing each case. Under 14, children may be sent to the homes for neglected children, and the result of all the different preventive organisations and agencies has resulted in a marked diminution of juvenile crime. Canada has, however, suffered from too short reformatory sentences, the average for girls up to 1900 being only 8 months, and for boys $17\frac{1}{2}$ months; this is now being altered. It is interesting to note that of the thousands of children emigrated to Canada from Dr. Barnardo's Homes and such like plces, only 3 per cent. relapse into crime, largely owing to the excellent Aid Societies.

Coming nearer home, up to 1905 European juvenile offenders from the Transvaal were sent to Tokai, but on March 1, 1909, a Reformatory was started on the Government Farm Houtpoort, in the Heidelberg district, where the staff consists of a warden, schoolmaster, gymnastic instructor, trades instructor, and garden instructor, children between the ages of 12 and 18 may be committed to the reformatory on conviction for not less than two years or more than five, but they must be discharged when 20, and they may also be apprenticed to some useful trade until 20. A Board of Visitors, consisting of three gentlemen, one lady, and the Resident Magistrate, report on every juvenile who has completed two years' detention, and thereafter yearly, making any recommendation they may see fit *re* conditional release, etc. An industrial school was also started outside Standerton for criminal juveniles under 18. This school is managed by a housefather and matron under control of a Board of Management consisting of four gentlemen, two ladies and the Resident Magistrate of Standerton as chairman. The housefather is assisted by a head schoolmaster, teachers, mechanician, carpenter instructor, tailor instructor, farmer instructor, laundress, seamstress, cook, etc., the school was opened just a year ago, and contains 64 boys and 44 girls. It will be noticed particularly, I trust, that these institutions are for white children only, the juvenile native criminals are all sent to a farm prison where they are instructed in farming.

In the Cape Colony, boys are sent to Tokai up to 16 years of age, but they are rarely sent there for a first offence, the custom in Cape Town at any rate is to create the criminal first and try and cure him afterwards. If a boy of 12, say, for the sake of argument, steals grapes, he is tried in the full publicity and unsavoury surroundings of the Police Court, and probably gets a month's imprisonment, which he spends comparatively happily, comfortably and easily in the precincts of Roeland Street Gaol, where he associates with habitual criminals, as indeed do persons

awaiting trial, who may by the way be found to be perfectly innocent, a monstrous state of affairs, which is a disgrace to the Province; our young prisoner is not burdened with much work during his month's detention, but he has every opportunity of getting thoroughly corrupted and of imbibing a profound contempt for the law. At the end of his month he is released, and probably promptly steals again, and gets three months under similar conditions; for the third offence he will most likely be sent to Tokai for five years, but, mark, he has been corrupted before being sent there at all. Nothing whatever is done for the boy after his first discharge from gaol, and the State having successfully corrupted him, turns him loose on society to engage in the fascinating pursuit of crime; it is only for serious offences that juvenile criminals are sent to Tokai, or after one or two convictions. At Tokai, everything possible seems to be done with, however, two exceptions. The white and coloured, though sleeping in separate dormitories, are in the same reformatory; I think they should be entirely and absolutely separated. The other mistake is that Tokai is a convict station, and the reformatory is surrounded with convict buildings, and the boys at work are in the same tainted atmosphere and neighbourhood, and in full view of hardened criminals in convict garb, not a very helpful environment for boys that the State is supposed to be trying to cure of criminal tendencies.

With regard to female juvenile criminals, at present the Salvation Army take into separate institutions European and coloured, both those awaiting trial and those convicted who are considered suitable for such form of detention; others are sent to the House of Correction, where they are associated with short sentence prisoners, but during working hours the hardened long-sentenced convict, the short-sentenced female prisoner and the juvenile are all together in the laundry, wash-houses, drying-yards, etc. It is impossible to write too strongly about such a state of affairs, which reflect the greatest possible discredit on those responsible. It simply means, as I said before, that the Cape Colony has been carefully creating criminals for years. I am happy to be able to state that the present Minister for Justice is fully alive to the state of affairs, and that as the Transvaal has always embarked on preventive work the Cape under Union is bound to follow. Under the Cape Juvenile and Woman's Imprisonment Act of 1904, juvenile prisoners of both sexes awaiting trial are supposed to be kept in some suitable place, away from the gaols, and for some time the Salvation Army Metropole was used for boys, but it was found unsuitable and discarded.

There has been some talk of the Social Farm at Rondebosch accommodating juvenile males awaiting trial, and also short-sentenced female prisoners, but I understand that not very much has yet been done in this direction, and I am of opinion that the Government should have its own institutions for these purposes under proper supervision.

The question of the proper treatment of criminals, of modern methods of prevention, of indeterminate sentences, etc., etc., are

most useful and fascinating, but in this short paper I am referring only to the juvenile criminal, and I would here state my very great indebtedness to Mr. J. de Villiers Roos, the Secretary for Justice, and Mr. Bright, the Acting Superintendent of Tokai, for information willingly and courteously given, and also to a paper delivered some time ago before the Royal Statistical Society by Miss Barrett. It took a Charles Reade to get the gaol system put on humane and common-sense lines in England; I don't pretend to be a Charles Reade, but I feel very strongly about the waste of our national assets, the children, and only publicity will do any good, and so I venture to try and get a scientific body to take some interest in a question of national importance.

It has been said that any fool can be a destructive critic, but it takes a wise man to construct; without wishing to pose as a wise man, I feel that having complained of the malady, I should try and point out the remedies in which I am much helped by the experience of older countries than ours.

First, then. From start to finish white and coloured prisoners awaiting trial or sentence should be kept absolutely and entirely separate.

Secondly, up to at least 18 years of age, boys and girls should be privately tried quite away from Police Court surroundings and under no circumstances should they ever be associated with or even see convicts. This means, of course, that either the reformatory or the convict station at Tokai would have to be moved. I sincerely hope the convict station will be and the reformatory kept for coloured lads only. For girls, separate industrial schools are wanted under careful and competent women; for this class of work Sisterhoods have proved most satisfactory.

Thirdly, before sentence, the juvenile should be detained in some suitable and pleasant place pending the most careful investigation being made into the circumstances of their homes and the causes of their delinquency. For instance, if a boy has—to revert to my previous illustration—stolen grapes, he should be sentenced according to all the circumstances; if his parents are respectable and it was a boyish freak, he should be returned to them with a warning; if his parents are not likely to help him he is probably much better in a reformatory for five years learning a trade, and if his parents are able they should be ordered to contribute to his support, as is done in the Transvaal, though perhaps in this class of case apprenticing to a respectable tradesman is a better method, but then it is very difficult to get just the right class of tradesman. But the magistrates must understand that the main idea is to make that boy an asset and not a burden to the State, and everything must be adopted with a view to attaining that desirable end.

Fourthly: The Transvaal system of Visiting Committees should be adopted throughout; they have already been referred to.

Fifthly: I would recommend applying to the Admiralty for a training ship to be moored in Table Bay, and send all the white boys in South Africa whom it is found should be detained for five

years there, where they may ultimately become of some benefit to the Empire, as at the end of the five years they would under certain conditions be drafted into the Navy.

I believe that if these suggestions were adopted, we would strike at the very roots of the monstrous growth which produces criminals; convicts were all children once; how far the want of a friendly hand, wrong methods, lack of sympathy, undue harshness and bad environment are responsible for their becoming a burden to the State it is impossible to gauge accurately. I may be considered as Utopian when I state that it is my profound conviction that no boy, whatever may have been his hereditary tendencies, is bound to become a criminal if he is caught young.

When perhaps he first falls, he may, can and should be cured of his unfortunate inheritance and made a useful member of the community and an asset to the country of his birth, as God meant him to be. It is the bounden duty of a State calling itself Christian to see that every child gets every possible chance to fulfil his Divine destiny.

TRANSACTIONS OF SOCIETIES.

Chemical, Metallurgical, and Mining Society of South Africa.—Saturday, January 17th. : Dr. J. Moir, M.A., F.C.S., President, in the chair.—"Stationary amalgam plates in tube mill plants": W. R. **Dowling.** A record of experiments conducted during a period of two months in regard to the substitution of stationary for shaking amalgamating plates, resulting in an increase in gold extraction by the tube mills amounting to over 1% of the screen assay value.- "The world's glycerine supply": W. **Cullen.** Remarks on the impending serious shortage of glycerine, consequent on the increasing consumption of explosives, resulting in augmented cost of the latter. The imperative need of experiment with a view to finding an effective substitute for blasting gelatine was urged.—"A grinding machine for zinc-cutting tools": H. **Brazier.** The author described his adaptation of a Liddell zinc-lathe as introduced by him at the Crown Deep extractor house.—"Native food supplies and their quality": F. W. **Watson.** Results of analyses of maize, imported flour, pea nuts, jugo beans, and cocoa were furnished and commented on.—"The mine dust problem": Dr. J. L. **Aymard.** The author discussed the ventilation of drives and the diffusion of foul air, and spoke of the medical aspect of the dust question, referring in particular to the production, prevention, and destruction of mine dust, the lighting of fuses, and the failure of water supplies.

South African Institute of Engineers.—Saturday, January 21st J. A. Vaughan, President, in the Chair.—"The Kimberley system of handling large quantities of ground in the minimum of time; with notes regarding the life of wire ropes": A. F. **Williams.** The author gave a detailed description of the plant in use on the Kimberley Diamond Mines, and explained the various systems of working, illustrated by tabulated working results extending over a period of several years.

DANTE'S TREATISE ON GOVERNMENT.

By Rev. Sydney R. Welch, D.D., Ph.D.

One excellent method of testing the validity of our political and social theories and dogmas is to place ourselves momentarily in those ages or amongst those philosophers whose views were very different from our own. For every generation of men gives its allegiance to some political views only because they persistently clamour for allegiance; and many a theory appears true enough simply because it has no fashionable rival. Fashion has its votaries to-day as ever amongst the politicians as amongst the scientists. It is a little difficult to resist the tyranny of fashion in any sphere; but it is well to try.

I propose, therefore, to look at some mediæval theories which are considerably out of fashion. In the Middle Ages there was a good deal of diversity of opinion on the subject of politics. But we may safely take Dante Alighieri as one of the great representative minds or the age in which he lived. His works reflect in a very vivid way the many-sided life of Italy at a time when Italy was the centre of European civilisation. He was the master mind that gave the Italians a language which was to soar above all their dialects "come aquila vola," an epic poem which in the opinion of many has had no superior in any clime or age. The *Divina Commedia* has been compared to a fine Gothic Cathedral for its perfect symbolism of all that is most divine and supernatural in terms of the most perfect human art; and on the other hand it has been called with equal truth "the diary and autobiography of the thirteenth century and of the Italian people," because it mirrors so minutely the thoughts and ideals of the people of that age.

The political views of such a man as the author of the *Divina Commedia* will always be worthy of attention. But in Dante's case there is a further reason for our respectful attention. His opinions were hammered into shape on the anvil of a long and bitter experience of active political life. He had passed through all the vicissitudes of political fortune; at one time having the highest office in the gift of his own Florentine republic, and dying an exile from his own land though in the honourable employment of a neighbouring prince. Out of the experiences of a life so varied and stored with the wisdom of antiquity, we have a right to expect some worthy lessons.

But in his great poem we look in vain for any clear or consecutive expressions of his political views. Hints of these views there are in abundance, but in that marvellous work of genius everything is subordinate to the chief aim which he never lost sight of, viz.:

"To make it also a handbook to Heaven, a treasure of religious sentiments, and of aids to the pe fection of the spiritual life." *

* Acton: "Dante and His Commentators."

We are, therefore, obliged to recur to a work written in Latin, which the poet meant to be an exposition of his theories of Government: the three books *de Monarchia*.

The very choice of Latin for the vehicle of the thoughts of his own Government shows that he intended to appeal to a smaller circle of his contemporaries and the larger circle of posterity. For he thought that the Italian languages were less adapted to give expression to philosophical speculation, and, being subject to constant change in the meaning of the words, a less durable record of his thoughts than Latin. He could hardly be expected to foresee that although his *Divina Commedia* with its "eloquencia vulgaris" would create a new literature, and be one of the world's imperishable monuments.

> Quod non imber edax, non Aquilo impotens
> Possit diruere, aut innumerabilis
> Annorum series et fuga temporum;

his laboriously planned work in Latin would be unknown to thousands who would have learned to revere the man who in the *Divina Commedia* had revealed the thoughts of many hearts.

If Dante could have been asked who his master was in political science, I feel sure that he would have answered, Aristotle. With the exception of the Bible no work is quoted more often than the Latin translation of the works of him whom Dante calls "il maestro di color che sanno.* "That glorious philosopher to whom most of all Nature has opened her secrets "† was the oracle to whom he looked for inspiration with regard to the political problems of the thirteenth century, because he firmly believed that behind the maxims of the Greek writer were the eternal dictates of reason. His attitude may be illustrated by the sentence with which he concludes one of his arguments based on a principle of Aristotle's :‡

> "Quod quidem non solum gloriosum nomen auctoris facit esse credendum sed ratio inductiva."

But let no one imagine that in the work *de Monarchia* Dante set out to give a mere rehash of Aristotle's Politics; with all his reverence for the Greek he expressly disclaims any such idea;

> "For what fruit would he bring forth who would again prove some theorem of Euclid? Or who would demonstrate once more the nature of happiness as Aristotle has done? Or who would again take up the defence of old age since Cicero has defended it? None at all; but such a tiresomely superfluous task would produce disgust,"**

An original mind like Dante's could not follow blindly in the wake of another. For him it was both a necessity and a moral duty to revise the opinions of his teachers and begin to build where they had left off. All those, he would say, who have the truth and have been enriched by the labours of the ancients have a duty so to work in the field that they have inherited, that posterity shall be the richer in truth because they have lived. Only these, he says, can lay claim to the blessing of the Book of Psalms: "he shall be like a tree planted by the rivers of water that

* Inf. IV 131.
† Com. III 5.
‡ de Mon., V. 19.
** De Mon., I. 20.

bringeth forth his fruit in his season." But the man who will not work in the garden of truth is "like a whirlpool engulphing all that comes its way, and never giving back the good things it has received."

Every man who wishes to discuss the problems of government must make up his mind some time or other what the main objective of a good government should be. The thirteenth century was at one with the twentieth in holding that all sound government must be in the true interests of the governed. And Dante lays down a broad principle which should be the fountain of true liberty, if a government is ever found that will put it fully into practice. *

This principle is a fair sample of the way in which the poet quotes Aristotle whilst he improves upon him and carries his meaning a step further than the author intended. First he cites these words of Aristotle (Pol. IV., 1-9):

"The laws are, and ought to be, relative to the constitution and not the constitution to the laws."

Hence Dante infers:

"Secundum legem viventes, non ad legislatorem ordinantur, sed magis ille ad hos."

But this is only the intermediate step to a more momentous conclusion:

"Although the consul and king are the lords of others, if we regard the means to be taken to secure the good of the state (this long sentence is necessary to explain the neat scholastic phrase, 'respectu viae'; if, on the other hand, we look at the end for which the state exists, they (king and consul) are the servants of others, and especially the emperor (monarcha) who is undoubtedly the servant of all. Hence also it becomes clear that the Emperor is constrained in legislating by this objective set before him."

The popular notion of an absolute monarch would not fit in with this scheme.

But so far Dante might walk in company with Jeremy Bentham and a host of other writers whose paths really diverge greatly. For serious differences arise when we ask: but what in precise terms is this aim which a good government should have in view? Is it the constant extension of the bounds of empire? Or a constantly increasing revenue from commerce? Is it any of the conflicting schemes of the Socialists? Or is it that strangely undefined thing, the greatest good of the greatest number? Some hundreds of similar questions have been asked by writers of note since Dante's time, and the answers have been more numerous than the questions.

But I am not here to discuss the relative merits of these answers, but merely to give you an idea of Dante's solution. As became a scholastic, his answer was clear and well-defined. He was able to assume, as an axiom of the current philosophy, that the highest possible natural development for the individual of our race was the fullest expression of his intellectual powers. For the whole human race the highest development would therefore consist in the fullest expansion of all the individuals of which it is composed. He concluded that it was the duty of the Governor to subordinate all lower aims to this.

* Mon. I, 12; I, 79; *sqq.*

Was the king, then, to turn schoolmaster or University professor? By no means. Intellect meant a good deal more than this to the men of the thirteenth century. The acquisition of mere knowledge and speculation were considered important parts of our mental activity, but they were only parts after all. Man being a reasonable being, his whole activity in every branch (art, science, politics, mechanics, etc.) must be controlled and ennobled by the mind, if it was to be worthy of him. Thus every province of man's empire over matter became a department of his intellectual development. It became the highest duty of the State to contribute in the best way it could, to the development of all its subjects along these lines.

An admirable but impossible scheme! someone may say. And such it would be, if Dante gave any encouragement to the idea of grandmotherly legislation, to make people healthy, wealthy and wise; as this programme would seem to entail at first sight. But no one knew better than the author of *Divina Commedia* that men's highest development should have its germ within. For when Vergil (the symbol of human wisdom and its devices in government or elsewhere) leads the poet to the threshold of the earthly paradise he leaves him with these words:

Non aspettar mio dir piu, nè mio senno.
Libero, dritto e sano è tuo arbitrio,
E fallo fora non fare a suo senno;
Perch' io te sopra te corono e mitrio. *

But up to that point in the poet's journey through the lower regions, Vergil had performed a very useful function. He had cleared away many an otherwise insurmountable obstacle from the path of this traveller in the regions of the soul. An analogous function in the development of nations is ascribed by Dante to the operation of the State. The government cannot turn out the finished product of the perfect man; but it can give all its subjects a fair chance of perfecting themselves according to their station and other circumstances.

It discharges this function best when it maintains a peace founded on freedom and justice. Peace throughout the world is, he holds, the best thing that can be secured for us by government.† Under the favourable conditions which it creates man will find his best opportunity for the noblest progress of every kind. When we find him attaching this high importance to the benefits of peace, we do not wonder that the well-known clause of the Lord's Prayer becomes in his verse:

Vegna ver noi la pace del tuo regno.

Given peace and justice between man, he believed that it was for individuals to carry on the highest work of the race. As long as the States policed the world and kept order, he believed that there was enough in man, to make actual every development of which his mind was capable.

* Purg. XXVII.139-42.

† Pax universalis est optimum eorum quae ad nostram beatitudinem ordinantur (Mon. 1.5.).

It would be interesting, but too lengthy an enquiry for our present purpose to trace the influence of contemporary history on this view of the poet's. The whole story of the time, we may say, is a confirmatory commentary on it. The history of our own times adds strength to his contentions. But that too is a long tale. We are compelled to pass to the second question which he raises: what is the best form of government?

What strikes one forcibly in first perusing the books *de Monarchia* is that the author discusses the best form of government for the human race. "Quite an abstract problem!" we might be tempted to say now-a-days. But then it was a concrete and a practical problem. The civilised world, as known to Europe, was not such a colossal organism as to make the thought of a single government an absurdity. The World-Religion had made the minds of men familiar with the ideal of a World-Empire; and the life of the European nations then reposed on a basis of a common religion. The dogma of the Communion of Saints had prepared the minds of men for the purely political notion of a brotherhood of man, and a family of nations under one paternal king.

When the student of politics looked abroad in the thirteenth century he found the Holy Roman Emperor in possession of a sceptre whose sway extended over the civilised globe, and was acknowledged on every side by all nations of Europe. He was the heir of the Caesars and especially of Augustus. He was the eldest son of the Church which men loved, and he was the official arbiter in all international quarrels. Henry VII. of Luxembourg, who wielded this sceptre when Dante was writing his manual of politics, was a sovereign who enjoyed the high esteem of his contemporaries. A Guelf opponent, Dino Compagni, describes him as "a wise and noble man, just and famous, thoroughly loyal, brave in battle and of noble line, a man of great capacity and great moderation." Friends and foes expected great things of him.

This was the aspect of the political horizon when Dante scrutinised the signs of the times. It may help to explain why he came to the conclusion that the rule of one emperor was the best form of government for the world as then known. There is no science in which theory so easily becomes the slave of a few irrelevant facts as the quasi-science of politics.

At any rate, having settled his conclusion, Dante defended it with all the ingenuity of a great mind. A single emperor of the human race was the best form of government, he argued, because the same order which exists in the parts of the human family (nations) must exist in the whole (c. 8); order on earth must be the reflex of order in heaven, where God reigns supreme and alone (c. 9); there must be a supreme judge to decide the controversies of kings and nations (c. 10); the emperor would have greater power to enforce justice, would be placed above petty ambitions, and would have a wider and so juster view of the good of humanity (c. 11); such a monarch could more easily be constrained to keep the public good in view, and would thus respect the liberty of his subjects (c. 12); one so highly placed would

have less reason for cupidity than lesser kings (c. 13); there is more chance of efficiency if the higher common interests of the race are in the care of one man, leaving smaller matters to princes and municipalities (c. 14); concord is best secured by one head (c. 15); Scripture speaks of the reign of Augustus, when Christ was born, as "the fulness of time," *i.e.*, the most blessèd time; but then the world was at peace under one monarch (c. 16).

This bare summary can give no adequate idea of the ability with which Dante defends his thesis. A synopsis is fatal to any but the soundest arguments. How many of our popular manuals of political wisdom would survive this ordeal?

I am far from wishing to hint that there is no real cogency in some of these arguments. Strip some of them of their mediæval dress, and you will find their substance in the speeches of the delegates to the Hague Conference in our own day. We are still searching to-day for a tribunal of international arbitration, and have not had much success in finding one. After two of the most terrible wars in history the last Hague Conference was as unlike a Parliament of Nations as such an assembly could be. And still this was what Dante not only sought, but what his generation to some extent found. They called it monarchy, which it was not; but at least they found an international arbitrator. We talk of the Hague tribunal, but its jurisdiction would seem to be very precarious. When Dante used the word monarch it may be doubted whether he meant much more than what we would call a President of the European Confederation. Of course he meant that President to be arrayed in all the trappings of a mediæval Emperor. Although the natural trend of an Emperor's authority was in opposition to national independence, Dante did not mean it to be so in his scheme. The Court of International Arbitration (if by a great stretch of fancy we can imagine it becoming anything outside the brains of the persons who conceived it) will be the fulfilment of one side of Dante's dream. So far then we may say that a not contemptible part of the political world holds the substance of Dante's theory of Empire, whilst being at a greater distance from its realization.

Thus far I have only considered the first of the three books of which the *de Monarchia* is composed. In the second, Dante stoutly maintains that the Roman people, whose heir he believed the Emperor of his day to be, were not only the *de facto* but the *de jure* rulers of the world. He finds many arguments for this, and amongst them the natural capacity of this people to rule, and the unselfish way in which it had discharged its responsibilities. We are reminded of the familiar boast of another Empire, nearer home, when we read his quoting with approval the eulogy contained in Cicero's words :—

> Imperium reipublicae beneficiis tenebatur non injuriis; bella aut pro sociis aut de imperio gerebantur; exitus erant bellorum aut mites aut necessarii; regum, populorum et nationum portus erat et refugium senatus. Nostri autem magistratus imperatoresque in ea re maxime laudem capere studuerunt: si provincias, si socios aequitate et fide defendissent. Itaque illud patrocinium orbis terrarum potius quam imperium poterat nominari.*

(* *De Officiis* II.8):

A magnificent tribute! if it were only true. Both Cicero and Dante believed it to be true.

In the third book we have a single thesis defended in the same way by a series of arguments in 16 chapters, appealing strongly to the principles held in common by all men then. He shows that the Emperor holds his power immediately from God, and within his proper sphere, has no superior on earth.

On a superficial view these may seem academic theses of antiquarian interest chiefly. But such a hasty judgment would miss their profound importance both at the time and for all time. For behind these innocent propositions lies the whole question of the relation between Church and State—a question of perennial interest, though it has quite a different form now.

Dante takes for granted that part of the theory of these relations which was common ground among lawyers and politicians in the Middle Ages. One of the most recent investigators in this field* has given us this ground of agreement in the form of a free translation from Stephen of Tournai, a Canonist of the Twelfth Century: "In the one commonwealth and under the one king there are two peoples, two modes of life, two authorities and a twofold organisation of jurisdiction. The commonwealth is the Church, the king is Christ, the two peoples are the two orders in the Church, that is, the clergy and the laity, the two modes of life are the carnal and the spiritual, the two authorities are the priesthood and the kingship, the twofold organisation is the divine law and the human. Give to each its due and all things will be brought into agreement."

But with this much agreement, there was still ample room for combat in theory and practice. The exact limits of the two jurisdictions was a field of frequent battle. But there was a graver issue than anything of this kind. Admitting that the Emperor had a field of government which was exclusively his own, how did he come by it? Was it inherent in his office, *i.e.*, did it follow from the nature of things? In other words: was his power immediately from God in this sphere? Or did he receive it mediately through some other delegate of Heaven? This was one of the debated points, which had a practical bearing on many acts of government.

Then politics intruded, as so often happens, upon the theoretical question and obscured it. Amongst the lawyers there were Guelphs and Ghibellines as these were in the field of battle and in the council chamber. The Ghibellines were the Emperor's party backed by the nobility, and they stood for the feudal privileges. The Guelphs were the Pope's party, the National party of Italy opposed to the Imperialists, they were supported by the people and stood for the rights of the free cities.

It was only natural that, in the heat of the fray, extremists on either side should exaggerate the claims of the head of their party. There were some canonists (only two have been discovered before the middle of the thirteenth century) who held that the

* "A History of Mediæval Political Theory," by R. W. & A. J. Carlyle, p. 198.

Pope was the only true Emperor and that the Roman Emperor was merely his vicar. On the other side were those who tried hard to establish a legal right inherent in the position of Roman Emperor, to intervene actively by way of veto in the election of the Pope. Both these positions were so evidently manufactured to serve the aims of a political party that they could have no attraction for moderate men.

And Dante was both a moderate and at heart an orthodox man. As Leo XIII. said in 1892: "non fu mai ch'ei fosse avverso d'animo alle verita della Christiana sapienza." There are isolated expressions and sentences in the *De Monarchia* which it is a little difficult to reconcile with Dante's general theories and with the spirit of the Canon Law; but they are usually the hasty outpourings of a great heart embittered by exile or the occasionally vague expressions of a great mind beating out new answers to questions asked by the events of the day. In the short space allowed me it will be impossible to deal with these details; I shall merely call attention to the outlines of his theory.

We may say that he was Ghibelline enough to uphold the independence of the Emperor within his own sphere; but also Guelph to the extent of not wishing the Pope to be dependent in any way upon the Emperor. Emperor and Pope were both God's vicars in different spheres.

He dismisses the difficult problem of the relation between Pope and Emperor in a few words. Although, he says, the Emperor is supreme in his own sphere, he is bound to wish to govern well; and this he cannot do without having due regard to revealed religion and to morality. Since the Pope is the official guardian of these interests in the Catholic world, it becomes the duty of the Emperor to consult him in spiritual matters. "The temporal power does not owe its existence to the spiritual, nor yet its strength, nor its importance, nor its operation, though doubtless it receives something from it, viz., to work better and more efficiently."* But Dante wisely refrains from defining these relations any further than custom and orthodox opinion had hitherto done. He hints that what is needed above all to make the arrangement work smoothly is a good understanding between those who have the rival powers in their hands.

For after establishing the independence of the civil power, he ends this treatise thus: "This truth must not be so baldly held, as if the Roman Prince were in nothing subject to the Roman Pontiff; seeing that this happiness of our mortal life is in a sense ordained to serve eternal happiness. Let Caesar, therefore, show that reverence to Peter, which an eldest son should show to his father." But there was no immediate conflict between these authorities when Dante wrote, and his allusion to them is therefore brief and merely to round the subject off.

The real preoccupation of the moment was the Emperor's authority in relation to the peace of Italy. That garden of the Empire had become a restless world infested with petty tyrants. It was divided into endless independent states and autonomous

* Mon. III, 4.

cities which waged incessant wars with one another; and their crowns were the stakes for which kings and princes played the intricate game of Italian politics. In the ardour of the game the people were too often forgotten, and they suffered accordingly. Peace was the first boon (only obtainable from a stable government), for which all good men sighed, and no one more ardently than Dante. Only thus could Italy be truly free, and no more pathetic cry of a stricken patriot was ever heard than his :

> Ahi, serva Italia! Di dolor ostello
> Nave senza nocchier in gran tempesta,
> Non donna di provincie, ma bordello.

Italy's natural guardians, the Emperors Rudolf and Albert, had not risen to the full height of their imperial responsibilities. Divided between the cares of a German kingdom and a Roman Empire, they were unable to do justice to both.

But at last Dante thought he could hail the dawn of peace in the appearance of Henry VII. in Italy. After having seen the vision of an ideal Empire, he thought that his eyes at last beheld the ideal man to rule it, in the new Emperor. Hence his leading idea in writing the *de Monarchia* seems to have been to strengthen Henry's power of healing his country's wounds by consolidating the theoretical bases upon which that power rested. If we bear this in mind we cease to wonder that he devoted a whole book to prove that this heaven-born hero was the heir of the old Roman Empire, which enjoyed such a golden reputation in the Middle Ages. We do not wonder when we see another book written to clear away any difficulties that the canonists may have alleged against the Divine Right of the Emperor.

But the irony of six hundred years gone by has settled upon all these questions now. Dante's treatise abounds in veiled prophecies of the new world that Henry would create. It reads to-day like an epitaph of the Imperial power in Italy. Henry died of fever in Tuscany in the year 1313, when the poet himself was an exile from Florence. Although few could have suspected it then, the Roman Empire was at an end in Italy for all practical purposes. As far as that country was concerned Dante's Empire was about to vanish from the earth at the very moment that the brightest visions of its future glory and usefulness were being recorded by one of the acutest observers of the thirteenth and fourteenth centuries.

SURFACE TENSION OF LIQUID SULPHUR.—An interesting series of observations with regard to molten sulphur, recorded by Prof. W. A. D. Rudge, of Grey University College, Bloemfontein, forms the subject of one of two papers by that gentleman published in the Proceedings of the Cambridge Philosophical Society, Vol. 16, Pt. 1. The paper is accompanied by photo-micrographic illustrations. Small crystals of sulphur were melted on a glass plate and formed spherical drops which flattened at 180°C, and still more at 260°C, but did not "wet" the glass until higher temperatures were reached.

A GEYSER IN SOUTH AFRICA.

(Plate 2.)

By Prof. Paul Daniel Hahn, Ph.D., M.A.

When I visited Rhodesia in June, 1909, I saw and heard much about this wonderful country; and I came away with the conviction that Rhodesia had a greater future than any other part of South Africa considering its unlimited agricultural and immense mineral resources. In addition to all these advantages, which form the solid basis of the future development of Rhodesia, there are many other objects of importance which attract the attention of all who take an interest in the future of this grand country. Foremost amongst these are the numerous mineral springs, of which one stands out as a genuine geyser.

I received the following information on this geyser through the kindness of C. L. Carbutt, Esq., Bulawayo, who has visited the spot several times and also supplied me with some water from the geyser for analysis. Mr. Carbutt gave me a photo of the geyser, which is a good illustration of the locality where the geyser occurs.

Mr. Carbutt writes :—

The water from the above geyser is emitted in a continuous stream, and thrown about 8 feet into the air. I cannot say how much water is thrown up per minute. The aperture from which it issues is a round hole about 1½ or 2 inches in diameter.

I am unable to give the temperature, never having taken it, but I should think it is slightly below boiling point, where the water leaves the ground. It is certainly far too hot to put one's hand into it. The geyser is situated near Fulunka's Kraal, about two miles south of the Zambesi River and 40 miles down stream, from the confluence of Gwai and Zambesi. The geyser is in the Zambesi Valley, at the foot of some low hills, running parallel with the river; it is well above the level of the Zambesi on a low spur of the above-mentioned hills. The country between the river and the geyser is covered with loose sandstone boulders. The geyser itself issues from what appears to be solid sandstone, with here and there a slight overburden of alluvial soil.

It is uncertain how long the natives have known this geyser, but doubtless for a considerable period. They do not consider it to be of recent origin. They assert that formerly there was a greater volume of water thrown to a greater height (about 15 feet, according to their indications).

The vegetation in the vicinity is the usual scrub bush of Rhodesia, which, as far as I know, has not yet been botanically classified: at any rate I am ignorant of the botanical or ordinary Rhodesian names of the plants. The natives do not ascribe any curative properties to the water, but rather that it exerts supernatural influence on crops, etc., and consequently propitiatory ceremonies are occasionally held round it.

From the confluence of the Gwai and Zambesi to the Kariba on the latter river, there are many hot springs on both sides of the Zambesi; none of them, however, take the form of a geyser. Round the geyser itself there is a considerable amount of hot water, springing from the ground in the ordinary way, and no doubt subterraneously connected with the geyser. The force with which the water is expelled is not great, as the geyser can be easily plugged with a stick, or the play of water prevented by placing over the aperture a stone weighing 10 or 12 lbs., nor does the force seem to be cumulative, for the activity of the

A Geyser in South Africa.

spring can be stopped until the obstacle is removed; it has not the power to blow a stick out of the hole, or a stone off the aperture. No doubt the surrounding springs act as a safety valve in these cases. The water has a slightly pungent smell, which seems to be accentuated in the mud over which the water runs. The mud when dry has a whitey-brown appearance.

No trees grow within about a hundred yards of the geyser, on the ground which appears to have been impregnated at one time or another with its discharges; only a little rank grass flourishes on this part.

From this description it appears that the Fulunka Geyser is not an intermittent but a continuously working geyser.

The quantity of water which was placed at my disposal was very small and I could only determine a few of the mineral constituents.

The waters of the geyser springs of Iceland have been analysed by Bunsen, Sandberger, Damour, Bickell, and many others. The most remarkable feature in the chemical composition of the mineral ingredients of the water of all geyser springs is the large proportion of Silica, of which the greater portion is mostly deposited as "sinter" in the vicinity of the springs. Whereas the water of surface springs or ordinary deep-seated springs rarely contains as much as one grain of Silica per gallon the waters of the Iceland springs contain a very large amount of Silica: the Great Geyser 35 grains of Silica per gallon, the Badhstofa Spring 18 grains, the Scribla Spring 11 grains. The other mineral ingredients of the water of the geysers are not of any special interest. But recently it has been observed that many of the hot springs and of the geysers are strongly radio-active.

The small quantity of water at my disposal was found to contain:—

Silica	13.65	grains per gallon
Alumina and Oxide of Iron ...	2.63	,, ,,
Magnesia	.65	,, ,,
Lime	1.50	,, ,,
Chlorine	2.11	,, ,,

The examination of the water for radio-activity must be made at the spring, since the emanation due to Radium as well as to Thorium rapidly escapes from the water.

There is no doubt that this interesting and important subject will receive due attention as the development of Rhodesia proceeds and reaches those regions in which the Fulunka Geyser occurs.

DARWINISM AND HUMAN LIFE.—Under this title the South African Lectures for 1909, by Prof. J. Arthur Thomson, have just been published by Andrew Melrose, London. In the course of a review of the book in a recent issue of *Nature*, exception is taken to Prof. Thomson's treatment of Darwin's term, the "struggle for life." It is held that confusion is caused by enlarging the conception so as to make it include resistance to adverse external conditions, or the strife between carnivora and their prey.

TWO METHODS OF FARM IRRIGATION.

By Charles Dimond Horatio Braine, A.M.I.C.E.

The proper handling of water in the field when irrigating—or leading, as it is often called in South Africa—is a subject that deserves far more attention from farmers and irrigation engineers than it has received in the past. I would impress upon you that the more carefully, and the more scientifically, you use water when irrigating, the better results you will obtain and, consequently, the more money you will make. The subject is one that should receive the earnest attention of every irrigator in South Africa, and I propose to direct attention to two methods—flood irrigation and furrow irrigation.

FLOOD IRRIGATION.

Many beginners start irrigating by trying to spread a sheet of water over their land. They think the ground looks level and even enough, and turn on the water; but, instead of spreading out, the water runs off to one side, collects in little pools, and runs all over the place, leaving strips of high ground quite dry. The water shows that the ground is not half as level as they thought. Some of them let the water go on running, hoping that the high places will gradually get wet by soakage from the sides. This is a horrible waste of water; it leaves part of the soil too wet and part not wet enough. Probably most beginners, when they see this happening, put on boys to level off the rough ground and throw the loose earth into the deepest places. When the water is turned off, they find that, although the high places are lower, the surface is more lumpy than ever, and the low places are filled with a layer of paste that will bake in the hot sun. The layer may be thick enough to stop many kinds of seeds, and sicken most of the plants that manage to push through it. A man who has heard of the "basin" or "check" system of irrigation may divide his land into plots, and surround them with banks of earth high enough to raise the water over all the high places. Now this basin system when properly used is quite indispensable in many cases, and is very extensively employed in all parts of the world. In Egypt some of the basins vary from 5,000 to 45,000 acres in extent. But our beginner is certain to find trouble with it, if the ground enclosed by the banks is rough and uneven; because as the water subsides he will still find pools of standing water. Many plants cannot stand that, and the crop will be patchy instead of being uniform, and there will probably be several bare places. On many soils, and for many plants, it is absolutely necessary to provide for a quick clearance of the water after the ground is wet enough.

One man may be surprised to find that the crops on the highest places are doing best, and that where the water was deepest they have not even sprouted. The deeper the water the worse will be

the result. This is due either to waterlogging the low places, or burying them under a layer of mud. Then again it means a shocking waste of water; because in trying to wet all his land he has used far too much water—water that should have been used on another piece of ground. If he wants to get a high duty, that is, if he wants to irrigate as much land as possible with the water at his command, he must arrange to use all the surplus water and not waste it. I remember once watching a farmer irrigate his field and was struck by the large quantity of water that poured off the lower end into a donga. This was an absolute waste of water, and took place at a time when all the farmers along the furrow were complaining of a shortage. If men irrigate like that they can never get the full value from the water.

The lesson to learn from this is that *the plot should have been graded to a uniform surface.* It is often difficult to induce beginners to realize the importance of doing this thoroughly; but it pays handsomely in the long run. For annual crops like oats, wheat, etc., it means a yearly loss of money; while for a permanent crop, such as lucerne, it means not only a loss, but the constant annoyance of knowing that you would be making more money if it had been properly done in the first instance. When lucerne is once well established, very few men would care to plough it, grade the plots, and plant again. Bear in mind the important fact that badly graded plots mean a waste of water, extra cost to irrigate, and almost always a reduced yield of crop. Be cautious how you economize in preparing your lands, for it may cost you far more every year afterwards.

Having levelled your ground, divided it into plots, and built banks round them, the next points to consider are the sluices for letting the water in and out, the quantity of water to use, and the rate of delivery. If the water comes in too slowly, it takes so long to spread that the top part gets more water than it needs and the lower part not enough. A large quantity is lost by evaporation: there is a waste of water and a waste of time. If you turn on too much water, the rush washes out great holes in the ground, and often washes out the seeds and young plants. The amount of water to be turned into one of your plots or basins can only be learned by experience. It depends on the soil, slope, etc. As for the basins, it is generally better to have them of a moderate size. I have heard of a basin in Mexico 1,000 acres in extent, and of others about 20 feet square. In California they range from about 200 acres to less than half an acre. With very extensive basins such a large flow of water is required that it becomes difficult to manage; while in small basins there should not be much waste of water. Some successful irrigators use basins about half an acre in extent; but much depends upon the shape of the land to be irrigated.

It pays an irrigator to devote some time and attention to the openings for diverting water into the basin or plots. Most of the irrigators that I know simply dig out a place in the bank and shovel the stuff into the furrow to form a dam. Then they dig out the dam and throw the stuff back to fill up the opening. Every time this is done there is a certain amount of earth washed away,

and I have often seen great holes in the ground three to four feet deep from which material had been taken for damming the water. This sort of work is bad, and there is no need for it. It is infinitely better to build permanent sluice-gates along the furrow, and others at the lowest ends of the basins to let out the surplus water. These gates should be well bedded, and the frames should run well into the banks on both sides. If this is not done you will have trouble from the water working its way round or under, and some day when you are not expecting it, a sluice may easily be washed out.

In extensive irrigation works it is absolutely necessary to build permanent sluice-gates across the large canals for dividing the water; but with small canals this is not necessary. An excellent arrangement is a sheet of iron semicircular in shape. This is a very handy arrangement, as it can be quickly carried from place to place. But it is only suitable for small canals, and should *not* be used for the openings into the basins, as the water would cut round it very soon. Another excellent method for quickly, easily, and cleanly blocking a canal is to use a piece of canvas cut roughly to the shape of the letter V, having a bar or narrow strip of wood fastened to the broad end.

The bar is placed across the top of the canal, and the loose end of the canvas laid upstream in the bed. If the edges of the canvas are pressed into the sides and bottom of the canal, it will hold for quite a long while. Some people drive a long spike through the small end of the canvas to help to hold it in position. These canvas sluices are very useful and handy; but they cannot be set if there is a large flow of water. They are suitable for moderate-sized furrows that are too large for the cheese-knife sluice mentioned above, and too small to make it necessary to build permanent sluices. But all the same, as soon as you have your canal in working order, and have decided how you are going to irrigate, I strongly advise you to put in permanent sluices; and this refers to any method of irrigation that may be employed.

After you have irrigated and sown you will probably see a crop come up bearing a look of promise; but suddenly it begins to look sickly, and as days go on the growth is patchy, being fair in some places, scanty, weak, or absolutely at a standstill in others. Most beginners think the remedy is to pour on more water as soon as the top of the ground looks dry, and the more they pour it on the less things may improve. Perhaps they have put on too much water, packed the ground too closely, and shut out the air that the roots require. It is not easy to say why standing water injures, more or less, so many plants by simply touching the stalks; but it is a fact.

The following points should be borne in mind, but they are only general, and subject to many exceptions depending upon soil, climate, and crop:—

(1). Nearly all plants are more or less injured by flooding when they are very young.

(2). A layer of fine mud may prevent many seedlings from coming to the surface.

(3). The deeper the water and the longer it stands the worse it is, especially with muddy water.

(4). The hotter the sun after the water is off the worse it is.

(5). High winds after flooding may cause more trouble than still weather.

(6). Most plants stand flooding better as they grow older, and many never do as well with flooding as with the furrow system, in which the water never touches the stem of the plant. This is the case with most trees and with many garden vegetables.

(7). Some plants, such as well-established lucerne on loose open soil, seem to do as well under flooding as under the same amount of rainfall.

(8) The injury from flooding is much less in damp, cool weather than in dry hot weather.

The real remedy for the troubles that may arise under the system of flooding is to have the ground so wet, and so thoroughly cultivated, that the seed will come up and *grow for a long time* without needing more water. It is difficult to induce some people to believe that ground thoroughly wet, and having the surface cultivated so as to cover it with a thick tilth, will carry a crop for several weeks without another irrigation; but it is nevertheless a fact, and in parts of America, where grain cannot be raised at all without irrigation, immense crops are carried by this means almost to the point of heading.

The injury caused by flooding appears to vary to some extent with the soil and climate, and you may find the results to be good in spite of the crops looking a little sickly at the start. I am not advocating flooding—I am simply trying to describe one of the recognized systems of irrigation; but a farmer who has to irrigate by flooding (and in many cases it is very convenient) had better find out as soon as possible its effect on the crops he intends to cultivate. If the soil is not too hard and tight, and water is not applied too frequently or too liberally, you may find flooding very profitable and convenient; but it is not always the best and is often the worst way to irrigate. You must be guided by circumstances and experience.

The basin system described is only applicable to land that is level or almost level; but where the slope of the ground is great enough for the water to move freely after the crop is up, a modified system of fairly long narrow strips of land enclosed by banks down the sides may be used with advantage. These strips must be level from side to side, so that the water will spread over the whole surface and flow down in a fairly even stream. If there is any side-slope the water will soon find it out and will flow down that side of the strip, leaving the upper part dry. These strips are sometimes made quite long, and vary in width from 10 feet to over 25 feet; but I think that as a rule they should only be moderately long, and a farmer should hesitate before he makes them over 300 feet long or over 25 feet wide. If they are made too long the upper ends get too much water.

To enable the water to run properly the slope or fall should be about 1 foot in 100 feet; but if there is a thick crop a greater fall can be used. In any case the water must not run fast enough to cut up the ground when first planted.

The strips must be carefully graded, and unless the ground has a long and easy slope requiring very little grading, and steep enough to ensure the required velocity for the water, they may be more expensive and less efficient than basins. In order not to waste water, the surplus at the end of the strip should be collected in a furrow and used on another piece of ground.

These two systems of irrigation by flooding differ in two important points—in true basin irrigation the ground is almost level, and small basins, if filled quickly, are practically covered with standing water, while with the long strips a sheet of water is run over the surface, and there is no standing water. In deciding whether to use flood irrigation or not, the following points should be considered :—

(1). If the slope is suitable, flooding is the cheapest method for handling large heads of water on large areas.
(2). Where the soil is very porous, flooding is often the only way to ensure quick and uniform wetting.
(3). Where the sub-soil drainage is bad and the ground is liable to become waterlogged, great care must be exercised in applying the water.
(4). Where the slope is too flat for the water to run in small streams, flooding is often the only method for doing quick work.
(5). The rate at which your water is delivered (on a large irrigation canal this may be very important).

The merits of irrigation by flooding may be stated very shortly :—*It is often the most convenient and most suitable method, though not the best for results.* An American irrigator of over twenty-five years' experience, who has written a long series of articles and is fully aware of the disadvantages of flooding and the advantages of other methods, gives his own experience in the following words :—

"I have a soil of several textures from near clay to the coarsest gravel. In spring when it is windy much of the time, and in summer when it is hot but rarely windy, I find it almost impossible to get a decent stand of anything without flooding."

He planted lucerne in the orthodox manner and it came up very badly. The seeds were then drilled in on dry ground and a big head of water rushed over the whole patch with excellent results. He goes on to say :—

"I have found it the same in a greater or less degree with about everything else. Even such a simple thing as a carrot I could hardly raise at all with furrow irrigation; but by thin flooding I can raise at least 20 tons to the acre."

These facts are given to show that every irrigator must adopt the methods best suited to the conditions of his farm, and that the beginner on a new piece of ground anywhere must study his conditions and find out the most suitable methods for the special crops he intends to grow.

FURROW IRRIGATION.

I will now describe an entirely different system of irrigation, one which, I think, will be largely employed in the future. As I

am not aware that it has a South African name, I will use the American term for it: furrow irrigation. This system is briefly this:—The land to be irrigated is covered with numbers of little furrows a few inches deep and about 3 feet apart. Down these furrows a little trickle of water is allowed to run for several hours at a time, and if the work is well done, the result is like the effect of a long slow rain. This system has been tried for years in the United States, and has been brought to a high pitch of perfection. It is like a constant, gentle rain, and under certain conditions makes the finest method ever employed for irrigation. The same American whose opinion on flood irrigation I quoted above says of this system:—

"Suppose you have a square ten acres in an orchard. It will be 220 yards on each side, and you want to put into the soil an equivalent of three inches of rainfall. As a cusec (or a flow of water equal to 1 cubic foot or 6¼ gallons per second) equals an inch of rainfall an hour per acre, it will need thirty hours to put the equivalent of three inches of rainfall on the whole. This would be far too slow for flooding, even in 25-foot basins. But if you can get 1 cusec for thirty hours you can do better work with small furrows; and if you can get it for sixty hours, you can do still better on many soils with only half a cusec, *i.e.*, a flow of 3⅛ gallons per second.

"It may seem quite absurd to divide such a stream into two hundred and twenty little ribbons of water, running only a little over a gallon a minute and spread a yard apart, and expect them to get anywhere. Yet that is exactly what is done in many a fine orchard, and to do it all you need is patience, and to remember that it is the greatest step in advance that was ever made in horticulture, and one that has been so thoroughly tested for thirty years that it will never go backward.

"You naturally remark that your soil will never hold up such a little stream to run 220 yards across the 10 acres. That is exactly where you may deceive yourself. It probably will if you give it time enough. Suppose you try it. Make a small furrow about 3 inches deep with the corner of a hoe, turn in such a stream and sit down and watch it. Or, better yet, go down town, or go to bed. If it will cross the 10 acres in ten hours with the land well graded to a uniform slope and with the furrow evenly made, it is all you should expect. If it will do it in fifteen, it is fine; if it takes twenty-four hours, it is good enough, provided you can have the water running for two days longer."

This system is largely used for orchard cultivation in the United States of America, and it is the one that seems to me most adaptable for steep ground. The system, however, requires suitable soil. In some soils the water does not spread sideways far enough; while in others, with furrows 3 feet apart, the moisture will meet 2 feet below the surface in half a day and 6 inches below in a day. The same writer quoted above states that, on his farm with furrows 5 feet apart, he has seen the moisture at the surface all the way between the furrows in cold cloudy weather. This, however, must be exceptional, and I would not advise any one to count on it doing it until he had made careful experiments. Where

the soil is such that increasing the size of the streams has no effect on the lateral or sideway soakage, then you must consider whether it would not be better to irrigate by flooding. At the same time, if the water between the furrows only meets a foot or so below the surface, it may show that the ground is better adapted for trees than for vegetables, etc.

This system works like a charm when properly arranged; but the grading of the furrows must be carefully done, and they must be kept clean. If they get blocked with rubbish of any sort, a little dam soon forms, and then you have two or more streams joining which may disarrange the other furrows. It pays you to have your furrows in good order from the start.

The even feeding of these furrows requires some little care and thought; for a large number of them must be fed at once, and if you wish to have an easy time, save labour, and not run back every few minutes to see that things are right, you must make a more or less permanent arrangement. It is a common thing for a beginner to attempt to let out the water directly from a large canal in a number of small streams to feed the furrows. In a short time some of them have cut down into the bank, and discharge so much water that the other furrows get none. He throws in a little mud, a few stones, a piece of old sacking, and, thinking he has made it all right, goes back to his lands. After a while he finds that instead of threads of water there is quite a stream rushing down behind him. His patched-up bank has given way again. Makeshifts are no good whatever. Do the thing properly and there will be no trouble.

With small canals it is possible to arrange for the delivery of water for furrow irrigation by placing sacks, half-filled with earth, along a bank. These must be fixed at such a level that when the canal is blocked the water runs over in a succession of small streams, each one just large enough for your small long furrows. But this method would be classed as a makeshift by many irrigators. Outlets properly made should be of wood, iron, masonry, or brickwork. Only in small canals can they be permanently fixed in the banks, and they must be so arranged that, when not in use, they are above the ordinary level of the water in the canal. With large canals, it is necessary to let the water into a sort of long trough or flume, and the trough must be fitted with the outlets to feed the small furrows.

Many irrigators find that the best results are gained by building a permanent trough or flume below the canal, with openings about one inch large every 3 feet. This trough can be supplied from the canal through a sluice, and the sluice can be set so as to discharge just the amount required to supply the trough. When not in use the sluice can be closed. When this is properly arranged small boys can do all the irrigating required. These troughs can be made of almost any material, and can be formed by planks, sheets of iron, or masonry walls along the lower side.

The beauty of this system is that the water is under absolute control, and can be used on steep sloping ground by carrying the furrows on a grade round the face of the hills. The velocity of the water can thus be regulated, instead of rushing down the

steep slopes and washing away valuable land at each irrigation. A farmer near Standerton, who is acting on the advice of the Irrigation Department, irrigates light sandy soil on a steep slope, and is getting quite satisfactory results with small furrows taken across the slope. If he attempted to irrigate in the usual way, all his land would soon be washed into the Vaal River.

For orchard irrigation, this system is probably the best for practical farming. No water need ever touch the trunks of the trees, and, by judiciously arranging the furrows, the roots can be induced to spread; that gives them a greater mass of soil from which to draw nourishment. After irrigating, cultivation should start as soon as ever the surface is dry enough. I am not dealing with fruit-growing, but I may add that, in the best orchards in America, cultivation is continued without intermission until the trees again require water.

This method of irrigation can be used for anything, but lucerne, etc., tend to choke the furrows after getting a good growth. When that happens a larger flow of water is required. There is nothing to prevent you from dividing your lands by small banks into strips 10 to 15 feet wide and flooding when the crop is thick. In this way crops can be grown on slopes so steep that they could not stand flooding until the ground was covered with a thick growth of vegetation.

CONCLUSION.

The condition of the sub-soil is a highly important point that requires careful attention, no matter what system of irrigation may be employed. I think that I am correct in saying that most irrigators in South Africa water their lands too frequently. Most of them seem to think that the great thing is to get the lands wet enough to plough, and wet enough for the seeds to germinate and sprout. In a few days they begin to wilt and the farmer thinks they need more water. So they do, no doubt; but they would not, if he irrigated properly. However, they need water, he irrigates, the young plants brighten up, and in a few days they wilt again. Well, they must have water, so he irrigates again, and the same performance is repeated about once every week or ten days. When treated like this any crop will be inferior both in yield and quality to what it would be if properly treated. This sort of irrigation is a waste of water, a waste of work, and a waste of money; and to make matters worse, if there should suddenly be a shortage of water, there would be a great risk of losing the crop or getting a poor one. But this is not peculiar to South Africa: beginners in other countries frequently make the same mistake. They don't think about the sub-surface soil; they forget that the proper place for most roots is deep in the ground and not in the surface layer; they perhaps do not know that roots will go to water, and if the top surface is damp and the sub-soil dry, the roots will remain in the surface layer; they overlook the fact that evaporation and heat will soon dry out all the moisture in the surface layer; in short, they have done nothing to induce the roots to grow downwards and to find their water supply in the lower layers of soil. In spite

of making these mistakes farmers make money; but they make less than they ought to for the amount of time, labour and water. They are not getting full value for their money.

Remember that the man who raises the greatest percentage of high-grade fruit or grain makes the greatest profit, and if there is a constant fluctuation in the vigour and growth of a tree or plant, you cannot expect a high-grade yield. If the water has been allowed to sink well into the ground so as to moisten the sub-soil, you will find that in many instances one irrigation a month will be sufficient for a large number of crops. As a rule you want a few heavy irrigations followed by thorough cultivation; if this is done conscientiously you will be surprised at the results. Something like 80 per cent. of the enormous fruit and grape crop in California is matured without any water after the fruit is set. This is simply because there is enough moisture in the sub-soil. If lucerne wilts on a dry sub-soil when it is between six or eight inches high, and before it comes into full bloom, probably one-third of that cutting is lost, perhaps even a half, no matter how quickly water is run over the top. But if the sub-soil is made moist enough you can often get a whole cutting with one single watering. I have known this done by some men in South Africa. As soon as a crop was taken off, the ground was heavily watered, the surface was well cultivated, and no more water was given until the new crop was off. A farmer near Bethal, who built an irrigation dam a couple of years ago, was advised by me that three irrigations would be enough for a winter crop. He wrote me less than two months ago saying that he could irrigate more land than I told him, and said "from an experiment made I find that if I irrigate ground, say in June or July, or even as early as the middle of May, and the ground is immediately ploughed, harrowed and sown, the moisture is retained, and no further irrigation required until the middle of September, by which time, with average luck, rain should do the rest for us."

On this point, as with many others connected with irrigation, there is no golden rule. You must study your sub-soil, and for this purpose I know nothing better than an earth augur. If you have a sub-soil of gravel, shingle, or boulders, your efforts to moisten it may be about as profitable as pouring water into a sieve, and if the sub-soil is pot-clay without facilities for drainage you may find your lands become waterlogged or sour.

You must not imagine that a damp sub-soil is all that is required for every crop. Strawberries and shallow-rooted plants require frequent waterings, because their roots never reach the moisture in the sub-soil. Varying conditions of soil, climate and crops modify the methods of irrigation. As a rule, *deep-rooted* plants require *heavy* waterings at long intervals of time, while *shallow-rooted* plants require *light* waterings at short intervals of time. That is the guiding principle: you must adapt the application to your requirements. If your soil is shallow, it will not require such heavy irrigations as deep soil; but on the other hand, if your soil is very deep, it may be a waste of water to wet it right down to the bottom.

A LOGICAL NOTATION FOR MATHEMATICS.

By Robert T. A. Innes, F.R.A.S.

Although my remarks apply to mathematics generally, the examples chosen will be confined to algebra, trigonometry and the calculus.

In algebra the learner is taught how to manipulate quantities which are connected by various signs for addition, subtraction, multiplication and division and the brackets; somewhat later he is introduced to the indices and the radical for square and cube-roots. When he fully understands that

$$si \text{ means } s \times i$$

he has to learn that

$$sin \text{ does not mean } s \times i \times n$$

and it is difficult to prove the logic in this distinction.

I advocate (1) the use of the ordinary Roman lower case letters, ordinary small type, italics and Clarendon type, and the lower case Greek letters, and these only to be used for symbols of quantity; these furnish a hundred different symbols and they can be manifolded by the use of suffixes as is so frequently done in astronomical formulae, but affixes should be barred as they are apt to be confused with indicial numbers.

(2) The capital letters of alphabets should be used purely and simply as symbols of operation. An example is the operation of E on x, viz.:

$$\mathrm{E}x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \text{etc.}$$

The rules suggested are, it is true, already partially in use. I merely recommend that in mathematics, the most logical of the sciences, they should be rigidly and, therefore, logically adhered to. Besides the gain in accuracy of form, the science will gain in simplicity and the learner will not be troubled with some of the absurdities which often cause real difficulties. It is known that the beginning of the differential calculus is a stumbling block to many; this is at least partially caused by that most illogical symbol of operation

$$\frac{d}{dy} \text{ which is not equal to } \frac{1}{y}$$

as taught in algebra.

The evolution of a satisfactory symbolical set of operators will take some time, but there is no reason why some of the more commonly used and simpler operators should not be introduced forthwith; especially do I appeal to writers of mathematical books for teachers in South Africa to make a start, the more confidently so as the translation from the logical system to the present one is easily learned. If we refer to books on mathematics which are over two centuries old, we are apt to wonder at the

notation the mathematicians of those days endured and to be thankful for the improvements of the century following. In the present age, such changes are more difficult to introduce, and there is a strong tendency to get "stereotyped" or fixed in a sort of Chinese arrest. This tendency should be carefully guarded against. If we consider the spelling of the English language, reform seems to be almost hopeless; although it is true that great simplifications of spelling have been introduced into Spanish, German, Italian, and I am glad to say the High Dutch used in South Africa. We have also a successful innovator in mathematics amongst us, I refer to Dr. Muir, who has softened our path in trigonometry by the successful introduction of the useful "radian."

The more obvious symbols of operation which should be adopted are—

New.		Old.	Meaning.
S	for	sin	(sine of)
C	,,	cos	(cosine of)
T	,,	tan	(tangent of)
L	,,	Log	(logarithm of)
E	,,	e	(exponential of) [already in partial use.]
D	,,	$\frac{d}{dt}$	(differential coefficient of) [already in partial use.]

The use of D instead of $\frac{d}{dt}$ is, as already remarked, not new, but it is rare. Should it be necessary to indicate the variable we should write $\overset{t}{\mathrm{D}}$. The sign $\int$ might be replaced by D_{-1}. Italic D might indicate partial differentiation. Some typical equations compare as follows:—

$$\frac{d}{dt}(uv) = u\frac{dv}{dt} + v\frac{du}{dt} \quad \text{with} \quad \mathrm{D}uv = u\mathrm{D}v + v\mathrm{D}u$$

$$\int u dx \text{ with } \mathrm{D}_{-1}u$$

The linear equation

$$v + x\frac{dv}{dx} + x^2\frac{d^2v}{dx^2}$$

transforms to

$$(1 + x\mathrm{D} + x^2\mathrm{D}^2)v$$

and thus avoids powers of the differential coefficient which seem absurd in a "Linear" equation.

These would carry the ordinary student over the usual range of his mathematics. He could be introduced to the effect of the operators S and C when learning algebra (immediately after Geometrical Series); and given exercises on

$$\mathrm{S}^2x + \mathrm{C}^2x = 1$$

and shown that he can separate the symbols of operation from those of quantity, thus:—

$$(\mathrm{S}^2 + \mathrm{C}\ )x = 1$$

etc., etc.

Here it is necessary to point out that convenience in printing justifies us in writing.

$$S^2x \text{ for } (Sx)^2$$

and that if we meant

S operating on Sx.

we should write it in the form S_2x. But it is only in higher mathematics that such forms are required. It is also only in higher mathematics that the real value of a logical symbolism is fully realised, but that is no reason why it should not be used throughout. We should never think of teaching children arithmetic by means of the Roman numerals. For instance, this simple sum requires some working out :—

MDCCCLIX multiplied by CLXXIV.

The solution of such sums might be a fine mental training, such as the learning of dead languages is asserted to be by some enthusiasts, but as a weapon of attack in the battle of life, it would be useless. So many students now learn mathematics with a view to its future use in their career as mechanical or electrical engineers, etc., that the subject should be taught them with the practical end always in view.

SLEEPING SICKNESS.—At a recent meeting of the Royal Society the Sleeping Sickness Commission (Col. Bruce and Capts. Hamerton and Bateman) submitted reports on experiments performed with a view to ascertain (1) whether antelopes may act as reservoirs for the virus of sleeping sickness, and (2) whether there was any possibility of the domestic fowl acting in such a manner. The conclusion was arrived at, in the latter case, that the Uganda fowl cannot act as a reservoir of the virus. In regard to antelopes a number of different species were procured from a district where tsetse flies and sleeping sickness were unknown. These bucks, after having been proved perfectly healthy, were subjected to tsetse flies (*Glossina palpalis*), and after lapse of a week their blood was inoculated into susceptible animals which, in every case, became infected with trypanosomes. Young flies, that had never fed before, were next fed upon the blood of the bucks, being subsequently transferred to monkeys which in due course became infected. The antelopes remained in perfect health during the four months that they were under daily observation, and two of them never showed trypanosomes in their blood.

CELTIUM, A NEW ELEMENT.—The discovery of a new element by Urbain in the gadolinite earths, where scandium and lutecium occur, was announced at the meeting of the Paris Academy of Sciences on the 16th January. A quantity of gadolinite had been worked up for the purpose of obtaining larger amounts of lutecium, and in the mother liquor resulting from several fractional crystallisations from nitric acid a new element was found to be present by spectroscopic examination. To this element it is proposed to assign the name Celtium. Its spectrum exhibits a large number of bright lines.

NOTES ON THE CONSTITUTION OF CERTAIN ROCKS OF THE ARCHÆAN AGE IN THE PROVINCE OF NATAL.

(Plates 3 and 4.)

By JAMES A. H. ARMSTRONG, F.G.S., F.C.S.

In a previous paper* I dwelt upon the existence of a narrow belt of granitic, gneissic and schistose rocks that traverse the Colony of Natal from north to south and which belong to the Archæan Age. In this paper I propose to deal with some of the more important rocks that would figure prominently in a vertical section cut through the narrow belt in Southern Natal, in the neighbourhood of latitude 30° 18′ south and lying between the 30° and 31° lines of longitude, and covering a distance of approximately 29 miles. Foremost among them occurs a whitish to greyish coloured gneiss which was dealt with macroscopically previously and which was stated to consist for the most part of quartz, felspar and mica. It is sufficient here to note that outcrops of this series are most numerous towards what may be termed the central part or zone of this belt. Microscopically this gneissic rock is seen to consist of a crystalline aggregate of quartz, felspar, mica and, last but not least, hornblende. The structure is holocrystalline and truly gneissic. The constituents, particularly the quartz which makes up the greater part of the rock, appear to be drawn out longitudinally in the direction of foliation and the hornblende with a quantity of felspar and the other minor accessories with small particles of quartz appear to be confined to the interstices between the quartz or the quartz and felspar lenticles. The quartz crystals contain numerous liquid inclusions and the action of the quartz in polarised light shows that it has suffered from the effects of straining. A like effect may also be observed in many of the felspars. Many of the elongated quartz crystals seem to extinguish in polarised light in successive parallel bands which vary in direction but slightly from the minor axis of each of the lenticles so affected. The hornblende is a dark greenish black variety, and the mica group seems to be represented by biotite, but this mineral is not present to any extent. Microcline is the chief felspar present and shows the characteristic cross-hatching. Another variety of triclinic felspar occurs and it also belongs to the acid end of the felspar series. The triclinic felspar shows twinning after the Albite Law and at times after both the Albite and Pericline Laws. In some instances I have noticed that the twin laminæ, although most marked towards the end of a felspar crystal, which had a tendency to assume an idiomorphic shape, almost become invisible towards the central parts of the crystal, or they may show a tendency to become spindle shaped. At times the twin laminæ, though parallel, are not straight, but appear curvilinear or wavy. The hornblende is sometimes visible in irregular patches and at times shows a fibrous structure. The felspar is often so decomposed as to be beyond recognition. The hornblende, though often affected by decomposition, is not so badly affected as the felspar.

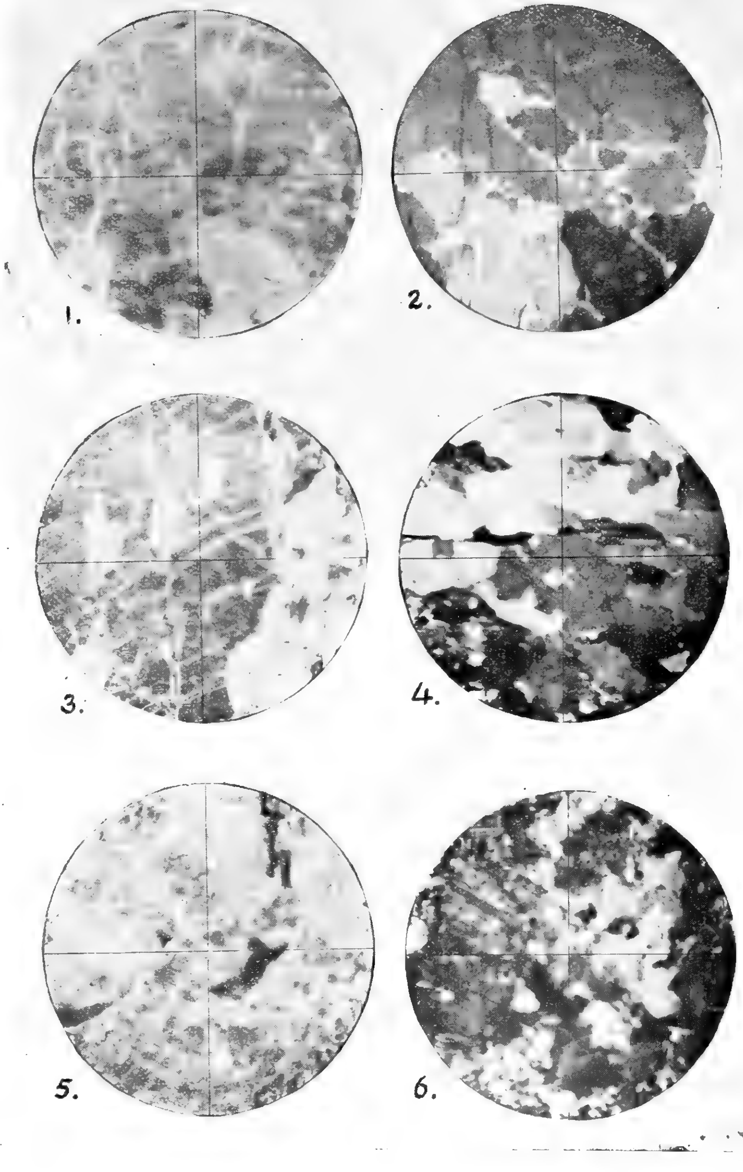
* Vol. 6, pp. 123 *et. seq.*

Throughout these gneissic rocks are to be found bands of quartz veins or leaders whose macroscopic features I referred to last time. It will be sufficient here to note their lenticular shape, their variability in width and in dip and the general coincidence of their line of strike with the lines of foliation of the component minerals of the gneiss. Their dip always coincides with the apparent dip of foliation in the gneiss. It is in these quartz veins I instanced the occurrence of gold in Natal, and I may mention in passing, from observations that I have made and which, though still incomplete, up to the present, show that it is not at all unlikely that most of the gold that is to be found in some of the parts of Natal rivers, the origin of which gold has long been a matter in dispute, may have been derived from those portions of these quartz veins, which have now vanished through the denudation of past ages. Remember also that these quartz veins were found to be connected with pegmatites. Hand specimens often appear to be a mass of pure quartz. Under the microscope this is found not to be so. They consist of a crystalline aggregate of quartz crystals, with some felspar and minor accessories, and possess a holocrystalline structure and are of igneous origin. The quartz is clear and with numerous liquid inclusions. It is traversed in parts by cracks and fissures. Within some of the quartz are scattered minute laths of greenish black hornblende. Some of the cracks must have been formed subsequently to the growth of the hornblende crystal inclusions, for at times well-defined laths of hornblende are also cut by these same cracks. The liquid inclusions often appear to be arranged in strings at right angles to these cracks. The laths are irregularly dispersed throughout the quartz but now and again a cluster may be found either with their longer axes parallel to the strings of liquid inclusions or to the fissures in the quartz. The quartz also shows that it has been affected by strains, and as it is in crystalline continuity with the quartz of the gneiss such straining may have been coeval. There is a small quantity of felspar of the variety microcline present and dispersed throughout the mass in somewhat idiomorphic forms. In appearance and optical characters it is the same as that in the gneiss. Very often it is in a very high state of decomposition, producing the same decomposition products as the felspar in the gneiss. A crystal of triclinic felspar of the variety albite may occasionally be detected in the quartz of the veins. Thus, then, we are led to the conclusion that what was suggested at the previous meeting from macroscopical features is borne out by microscopic analysis, viz., that these quartz veins, which appear to be confined to this type of gneiss and which cross the country for miles, represent igneous intrusions in the gneissic rocks by a somewhat more acid magma at the time of or soon after the origin of the original gneissic rocks and before their conversion to a true gneiss. Underlying this gneiss is granite varying in colour from white to red—the variation in colour depending upon the colour of the felspar present. The rock presents the crystalline structure visible in ordinary granites, and consists of an admixture of quartz, felspar, hornblende and a little mica. The quartz is similar in

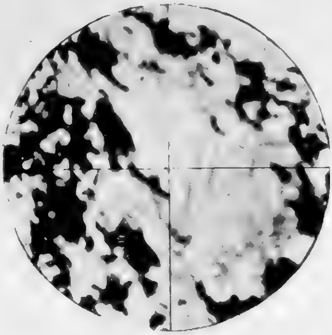
appearance to that in the gneiss, but is of course not drawn out into lenticles. The crystals have crystallised in allotriomorphic forms. There are numerous liquid inclusions present in the quartz, but on the whole comparatively few of the particles show the effects of straining to anything like the extent that those in the gneiss do. Numbers of quartz crystals show no effects of straining at all. The felspar group is represented chiefly by microline. The cross-hatching is distinctly visible. Decomposition is not so marked as in the case of the gneiss. Still there are but few of the felspar crystals that do not show the effects of straining by their optical behaviour. Albite is also present. The mica is the variety biotite and the hornblende is a dark greenish black variety. The decomposition products in the felspars appear to be Kaolinite. Occasionally may be seen instances of the interlamination of the members of the felspar group, thus giving rise to the microperthite structure. In addition to this, examples may be found of the intergrowth of felspar and quartz, producing a micropegmatite structure. On the whole the general agreement of the mineralogical constituents of the underlying or associated granites with those of the gneiss lends considerable support to the theory hitherto mentioned by me that the gneiss, which forms a sort of backbone to the rocks in this part of the country, was derived from the granites themselves through the effects of metamorphism produced or to a great extent produced by terrestrial disturbances. Reference was made by me, in my last discourse, to the fact that these granitic rocks had been intruded by basic rocks at two different periods. Although full reference was then made to the macroscopic features, little could be said as to the real mineral constituents or nature of the intrusive rocks owing to their state of decay. However, I have now unearthed portions of these rocks to permit of their determination. The older type of igneous intrusive rock consists of an admixture of hornblende, felspar and quartz. The hornblende is by far the most plentiful constituent. In fact so great is its presence that, to the naked eye, the rock presents the appearance of a dark basic crystalline rock. The hornblende is a dark greenish black variety. In fact it is the same variety that pervades the granite and gneiss. Except for the occurrence of a flake of biotite here and there, mica may be regarded as absent. Twin crystals of hornblende are sometimes to be seen. The hornblende also shows a high relief, strong pleochroism and the cleavage angle reaches 124°. Whilst in the granite, and more conspicuously in the gneiss, the felspar shows twinning on the albite type and at times most markedly both on the albite and pericline types, in this type of rock pericline twinning in the felspars is conspicuous by its absence. In fact, many of the felspars here present show but a meagre trace of twinning on the albite type. Microcline is not present, so far as my examination shows. The rock is holocrystalline. Next in abundance to hornblende may be mentioned the felspars, which are wholly triclinic in variety. The hornblende, following the usual rule of Rosenbusch as to basicity, has preceded the felspar in the order of crystallisation. The felspar, quartz and some of the hornblende has crystallised in an allotriomorphic form, but some

of the quartz and felspar appear in somewhat circular blebs. A fact worthy of note is this, that where the hornblende crystals in the sections have been cut parallel to their vertical axis the vertical axes all appear to lie in parallel lines as if following the line of fluxion or flow. Occasionally a quartz crystal may show a trace of straining. The quartz does not contain liquid inclusions to the extent it does in the other varieties of rocks mentioned. The felspar appears to be the variety Labradorite, with traces of cleavage cracks, along which decomposition has in many instances commenced. It is worthy of note that both the quartz and felspar contain well-defined crystal inclusions of apatite and zircons. Leaving this type for the present, I will meanwhile touch upon the second type of intrusive rock, or, as it may well be styled, the younger series. This rock is holocrystalline in structure and non-porphyritic. It consists of an admixture of triclinic felspar, augite and other accessory minerals. The felspars are columnar and show elongated sections, with no law of arrangement, and around or between them the augite is moulded. It represents the Ophitic structure typically. There is a fair quantity of magnetite present and a small quantity of ilmenite, which is associated with its usual white decomposition product, viz., Leucoxene. The magnetite has also suffered through decomposition, and thus many cracks and fissures, which traverse both the augite as well as the felspars in diverse directions, are filled with iron oxide stains which radiate from the decomposed particles of magnetite. The magnetitite is found in crystals as well as granules. Where the grains or crystals of magnetite have been small they have almost entirely disappeared and left a reddish brown stain of iron oxide on the spot where they once were, and have also filled up the cleavage cracks in the vicinity of the somewhat circular spot of decomposition product. At times a piece of partially decomposed magnetite is to be seen in or about the centre of the spot. The augite shows little or no pleochroism and has the usual cleavage angles of 87° and 93° or thereabouts. The augite shows good cleavage planes, and is on the whole not badly decomposed. The felspars show the albite type of twinning. Twinning on the pericline type is less common, and an occasional instance occurs of a felspar twinned on the Carlsbad type. The triclinic felspars present belong to the basic end of the plagioclase series of felspars. The principal variety is labradorite. This rock then may be regarded as a diabase. Let us now look at the rocks which occur in this belt and that lie nearest the coastal side of it. They extend from this central zone to almost the coast, where they are overlain by the Table Mountain Series and other formations. They outcrop at intervals and thus extend for some miles. To outward appearance, they are of a very dark greenish black to black colour, and the various minerals, in some of the outcrops where the rocks have been bent and folded into anticlinal and synclinal folds, appear to be arranged along lines of foliation parallel to the direction of the fold. In other places where the rocks have not been contorted thus, no such arrangement of the component minerals occurs. Here and there throughout the narrow belt are to be found instances of a commingling of this

dark-coloured rock with the gneiss and some of its associated rocks above referred to. The commingling often takes place in a most erratic manner, but on the whole discloses the fact that the dark basic rocks have intruded the other series. Often a clear line of contact can be drawn between the two series except where their line of contact or junction happens to be in the vicinity of great contortions of the rocks. Throughout local areas, often of great extent, these dark-coloured rocks have been intruded by light grey, yellow or whitish-coloured rocks of a quartzose nature. The veins vary in thickness, and in some places traverse or cross and recross the rocks in a most erratic manner, whilst in other places, where these rocks appear foliated, these veins seem to follow the line of foliation in fine parallel bands, with an occasional instance of a vein breaking through the rocks above or below and continuing its course in a higher or lower plane than that which it orignally had. At places where they have been swollen out to a thickness of over a foot they have assumed a pegmatitic character. I have found that some of them intrude other more definite formations, such as the Dwyka Conglomerate, and thus their age must be at or subsequent to Permo-Carboniferous Times. However, they are a study in themselves, and will be investigated by me at some future time. It will be sufficient here to note their intrusive nature and that they do not appear to be connected with the quartzose veins mentioned in the former part of this paper, but are evidently a younger series. These dark rocks have likewise been intruded by the type of diabasic rock referred to above. A pretty scene may at times be seen in the bed of a river or stream eroded out of this dark rock in those parts where it has been intruded by these parallel veins. The dark rock being more prone to decomposition, has weathered away, leaving the harder type of white intrusive rocks in low parallel ridges. Under the microscope this rock is seen to consist of principally triclinic felspar, hornblende, mica and a small quantity of quartz, as well as minor accessories. The mica is not present in any quantity. An occasional flake of biotite is all that is to be noted. The hornblende, which is present in some quantity, and which with the felspar by far makes up the greater part of the dark rock, is a dark greenish black variety—the same in every respect to that in the type of basic intrusive rock previously referred to and in the gneiss. The felspars present are wholly triclinic in variety, showing twinning after the Albite Law, with occasional twinning after the Pericline Law. The structure is typically holocrystalline. The felspars are very much decayed. The decomposition products being, as in the other cases referred to above, principally Kaolinite. The felspar is chiefly the variety labradorite, and the other varieties range in the order of basicity very near to this variety. The quartz when it occurs usually has a somewhat circular form and does not contain on the whole so many inclusions as in some of the other instances. Among the accessories may be noticed magnetite. This occurs mostly in granules, though an occasional crystal is to be found. Where the hornblende has weathered some parts show bleaching with a separation of magnetite. An occasional scale of haematite is to



Rocks of Archaean Age.



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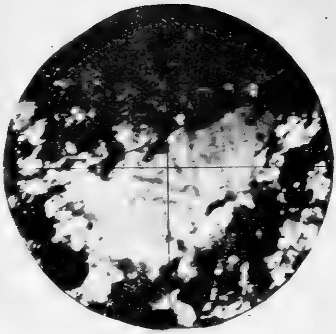

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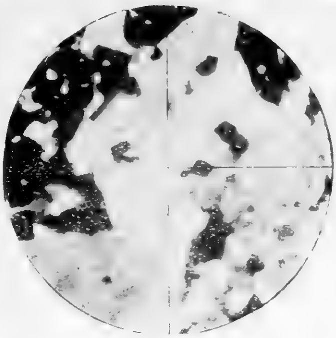

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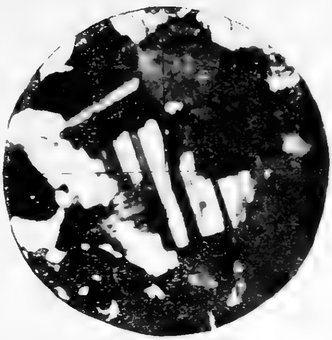

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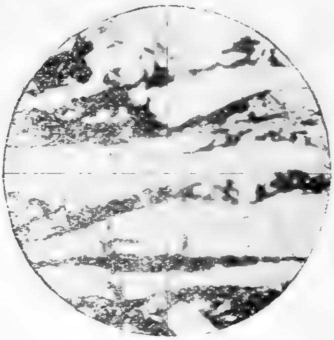

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Rocks of Archaean Age.

be found. The felspars and quartz contain numerous crystal inclusions of zircons and apatite. A marked similarity is thus apparent between this type of rock and the rocks of the older type of intrusions mentioned above. Now for a glance at the rocks occurring in that portion of the belt that lies between the central zone of gneiss and its western limits. These too are very complex in character. Unfortunately the line of junction between them and the gneiss is not visible so far as I have seen, and thus much information is withheld from view. Outcrops occur that present to view rocks of a crystalline granular nature, whose components have attained a large size and exhibit a speckled aspect produced from the intermixture of greyish and greenish or reddish and greenish or greenish and blackish coloured constituents. So great is the diversity in colours of one and the same or of the different minerals. Other outcrops may exhibit a similarly coarsely crystalline rock with large well-formed crystals of felspar standing out within the crystalline matrix and illustrating well the porphyritic structure. I have seen rock of a similar nature jutting out from the sea near Camps Bay, Cape Town. Again intermingled with these or either of them or associated with them is to be found a type of a dark basic-like rock. The basic rock is so intimately connected with the associated rocks and is usually of a finely crystalline nature that from the features in the field obtained from an inspection of the limited outcrops it would be difficult to render any opinion as to its nature. In the so-called porphyries the felspar is set in some cases in a quartz matrix which from the marked parallelism of the longer axes of the felspars and the homogenous nature of the quartz cement is indicative of the former fluidity and flow direction of the ancient acid magma. At places some of the constituents have disappeared from the quartz cement through decay and the remaining cavities give the matrix a pitted or porous appearance. Very often the so-called speckled rocks weather into huge blocks along divisional planes which may mislead anyone looking at them from a distance into the belief that they marked the site of an outcrop of sandstone. The sudden change that takes place in the nature and colour of the soil and at times of the vegetation and grass too within these confined areas marks the change in the underlying rocks. This is borne out by the examination of the soil in the neighbourhood of outcrops. These rocks are overlain unconformably by rocks of different formations ranging from the Table Mountain Series upwards. The difference in the colour of the so-called speckled rocks is due entirely to the wide range in colour assumed by the felspars. Such are the changes which occur and recur in the western section of the belt. Microscopically these somewhat coarsely crystalline speckled rocks are found to have had a former porphyritic structure. They are holocrystalline in character, and the rock consists of an admixture of felspar, quartz, and hornblende as essential minerals, with several accessory minerals. The felspar is the most abundant of all the constituents. Then quartz but they possess the same mineralogical characters and structures. Besides, they occupy a minor part in the constitution of the rock compared with the base. The hornblende, which is confined to

comes next, with the hornblende in much less quantity. The felspar is usually present in huge crystals, and so is the quartz, but the latter mineral does not quite attain in size that attained by the felspar. These larger constituents are set in a microcrystalline admixture of felspar, quartz and hornblende. The phenocrysts of felspar and quartz appear to be pulled out longitudinally and are at times found to be corroded. The hornblende, which is usually a dark greenish black variety, occurs usually in irregular patches, seldom of any size, and less frequently in laths which are, when found, of small dimensions. Its similarity in mineralogical composition to that of the other rocks already mentioned cannot be doubted. At times there is to be seen a flake of brown biotite. The quartz does not contain so many inclusions as in many of the other rocks instanced. The phenocrysts of felspar rarely show any types of twinning, but where this does occur it takes place either after the Albite Law or after both the Albite and Carlsbad Laws. Among the microcrystalline admixture of felspar, quartz and hornblende that fills up the interstices between the phenocrysts of felspar and quartz twinning in the felspars, although of more frequent occurrence than in the phenocrysts themselves, is scarcely noticeable, but where it does occur it is usually after the Albite Law and seldom after the Pericline Law. The quartz crystals or granules bear evidence of having endured some strain. This type of rock must have been originally of a porphyritic nature, and it must have suffered from metamorphism. Well-defined cleavage planes are noticeable in many of the felspar phenocrysts, and some of the specimens are very pure, but others show traces of decomposition taking place. As in the case of the other rocks already mentioned when decomposition starts it takes its rise first in the cleavage cracks, and with similar results. The felspars, as with the quartz granules, are often traversed by irregular cracks, and this is more noticeable in the large phenocrysts. With regard to the arrangement of the minerals in the microcrystalline base, it may be worthy of notice that the coarse-grained particles are always confined to the central part of the interstices and the finer-grained particles lie between them and the phenocrysts. It often happens that the quartz and felspar have crystallised together within certain areas in those parts where the base is most finely microcrystalline, and have thus given rise to a micropegmatitic structure. These patches are always adjacent to the sides of the quartz or felspar phenocrysts. It may be a case of the vitrification and recrystallisation of the small particles through the metamorphic influences. The felspar, which is triclinic, seems to range with regard to basicity in the neighbourhood of that of labradorite. Let us now look at the microscopical structure of the black coloured rock, which is associated with the above type of rock. It does not differ as regards its mineralogical constituents from those above mentioned, saving that, although holocrystalline in character, it consists for the most part of the microcrystalline base of the above type. It is also found to contain phenocrysts of felspar and quartz scattered throughout its mass, but they are comparatively few in number and small in size compared to those in the other type of rock,

the base, is the usual dark greenish black variety, and is present in some quantity, and is further marked as occurring chiefly in irregular patches. The minute fragments of quartz show signs of having borne some degree of strain, but twinning in the felspars is rarely to be seen. As with the more porphyritic variety, so in this may be noted accessory minerals, such as zircons and magnetite. With these remarks, then, may be drawn within a certain degree of certainty certain conclusions as to these ancient rocks in this belt :—

(1). The original rock seems to have been a greyish to reddish coloured granite with hornblende conspicuously present as one of its constituents.

(2). Overlying the granites are gneisses which must have been derived from the original granites through metamorphic agencies.

(3). Throughout these gneisses but confined to certain belts are bands of parallel quartz veins, which are associated with ancient pegmatites, and which mark the occurrence of intrusions in the gneiss at or soon after its origin but prior to its metamorphism by rocks, probably parts of the same igneous magma, of a more acid character.

(4). Intrusions in the gneiss by rocks of a dioritic type which are evidently connected with and portions of the dioritic rocks which are found on the coastal side of the narrow belt and which may represent more basic portions of the original igneous magma from which the gneiss was derived.

(5). Intrusions in the gneissic, granitic, schistose and dioritic rocks by rocks of a typical diabasic character.

(6). The occurrence of metamorphic porphyritic rocks in the inland portions of the belt and which undoubtedly were connected with the original fluid magma and represent more basic portions of it.

I may mention that there appears to be a two-fold division of granites in Natal—a younger series and an older series—but, much as it has been my desire to touch upon the younger series and its pegmatites, and the differences between the two series and other wide problems, my unaided investigations and efforts have had to submit to the restraint of that desperate enemy "Time."

EXPLANATION OF PLATES.

1 and 2. Vein Quartz with cracks and inclusions and decayed felspar.

3 and 4. Gneiss, showing cracks and decayed felspar.

5 and 6. Granite, showing state of decay of felspar.

7 and 8. So-called black porphyrite : felspar phenocryst in centre.

9. So-called black porphyrite, metamorphosed.

10 and 11. Quartz diorite.

Nos. 1, 3, 5, 7, 9 and 10 in partially subdued transmitted sight.

Nos. 2, 4, 6, 8 and 11 in polarised light. All magnified 60 diams.

ON THE PERIOD OF THE VARIABLE STAR S *ARÆ*.

By Alexander William Roberts, D.Sc., F.R.A.S., F.R.S.E.

R.A. 17h. 51m. 27.3s. (1900).
Dec. 49° 25′·3

This remarkable variable star was discovered by Innes at the Cape in 1898. He also determined its period and light curve. Observations were begun on the star at Lovedale in 1899, and have been carried on until the present day.

The period submitted by Innes in the "Revision of the Cape Photographic Durchmusterony," page 128, B is :—

10h. 50m. 43.5secs.

A discussion of the observations made at Lovedale from 1899 to 1909 yielded a period of :—

10h. 50m. 43.45secs.

Now the purpose of the present paper is to discover if this period is constant or variable, and if so to what nature and extent.

This inquiry is important as it bears directly upon the genesis and evolution or devolution of the system S *Aræ*.

If the period of any binary system be constantly increasing then the correspondent members of the system are slowly drifting apart, a result due either to tidal action or to the loss of material from one or both components.

If the period of any binary system is uniformly decreasing, then the two components are slowly approaching one another, and will at some remote date coalesce. This approach may be due to a resisting medium retarding the movement of either one or both components.

Instead of taking maxima dates as a basis of our investigations, we take eight mean dates when the star passed through 10.0 magnitude on its upward trend.

These dates are in Julian days :—

d.	h.	m.
2,415,202	0	53.4
5,286	13	52.6
6,648	2	13.0
7,009	14	33.3
7,732	15	6.4
7,913	9	19.8
8,455	15	46.0
2,418,862	8	30.0

Dealing with these in the usual manner yields for S *Aræ* the Elements of Variation :—

$$2{,}415{,}021^{d.} \quad 6^{h.} \quad 41'.3$$
$$+ 10^{h.} \quad 50' \quad 43''.624E$$
$$- 0''.0000245E^2$$

The secular term in the above,

$$0''.0000245$$

is the important fact, as it indicates that the period of S *Aræ* is slowly decreasing.

This decrease is

$$0''.000049$$

each revolution of the secondary star round the primary.

At first sight this may seem an inappreciably small quantity ; but in ten years a lagging each period of

$$0''.000049$$

will aggregate to a lateness of ten minutes on the scheduled time of maximum, an amount readily discernible in a star so rapid in its changes as S *Aræ*.

Further, although the secular diminution in period only amounts to a decrease of five minutes in a thousand years, this in the life history of a star is but a very small span.

So that if the decrease in period of S *Aræ* is a constantly accelerating quantity, as it may possibly be, if it is due to the action of a resisting medium, probably an extended but tenuous atmosphere round the primary star, through which the secondary star has to pass, then the end of the star as a binary system is not remote.

It is possible that the secular change in period is cyclical, however, and that an increasing stage will follow on the diminutive stage, which is at present in operation.

The problem of the evolution and life history of a star is internally bound up with the question of period, and it is because of this that the present paper on the secular diminution of period of S *Aræ* is submitted.

POISONOUS NATURE OF KAMASSI WOOD.—The Kamassi tree, or South African boxwood (*Gonioma Kamassi*) has been used in Lancashire at times for the manufacture of shuttles, and symptoms of poisoning have occurred amongst the men engaged in operating upon the wood. The latter was accordingly submitted to chemical analysis, and Dr. W. E. Dixon communicated to the Royal Society, at its meeting on the 19th January, the information that the wood contains about .07 per cent. of an alkaloid belonging to the curare group. The physiological action of this alkaloid comprises paralysis of the nerve cells in the brain and medulla, strychnine-like convulsions if injected into a vein proceeding to the spinal cord, and paralysis of motor nerve endings. The recorded cases of poisoning are believed to be due to the effect of the substance in facilitating local reflexes of a respiratory nature.

OCCURRENCE OF A SPEK-BOOM IN THE TRANSVAAL.

By JOSEPH BURTT DAVY, F.L.S.

A kind of Spekboom, a species of *Portulacaria,* family Portulacaceae, has been found in the Lydenburg district of the northern Transvaal. It occurs at about 4,300 feet altitude, on the old trek-road to the Pilgrim's Rest mines, at a place where the road formerly crossed a strong stream, a tributary of the Steelpoort River, by a drift, now abandoned for a substantial bridge. The stream is called the Spekboom, and was probably so named by transport riders who knew the Spekboom bush of the Eastern Province. It is also reported from a similar situation on the Olifants River, north of Ohrigstad, and below its junction with the Steelpoort. I am indebted to Mr. Harry Harber, of Grootboom, Ohrigstad, for information and specimens. The latter do not appear to differ from specimens of *Portulacaria afra* Jacq., which I have collected in the Fish River Valley, Albany Division, but I have not seen flowers.

The occurrence of a species of *Portulacaria* so far north is particularly interesting, for the genus is not known to occur elsewhere in the Transvaal, nor at all in the Orange Free State. The nearest point in the Cape Province, as far as I can learn, at which the Spekboom occurs, is in the vicinity of Cradock, a distance of fully 600 miles from Lydenburg in a bee line. Mr. Medley Wood notes the occurrence of *Portulacaria afra* Jacq. in Natal, below 2,000 feet altitude, but there is no apparent phyto-geographical connection between the Fish River basin, Natal, and the Upper Bushveld region of the northern Transvaal. One would expect that occurrence in remote localities, separated in the one case by the mountain chain of the Drakensberg, and in the other by 600 miles of high plateau, would result in marked specific differentiation, and a careful study of specimens from each locality is desirable from this point of view.

In the *Flora Capensis, Portulacaria afra* Jacq. is recorded only from the districts of Uitenhage, Graaff-Reinet and Albany. Mr. Sim records that it extends from the Sunday's River to beyond the Kei, and from near the coast to Cradock, but that it does not occur beyond the Amatola or Winterberg ranges and is less abundant eastward.

The only other species of the genus, *Portulacaria namaquensis* Sond., occurs, as its name indicates, in Namaqualand, to which region it appears to be confined. In this case the expected has happened and distinct specific characters are found.

NOTES ON THE OCCURRENCE OF GOLD IN THE PRINCE ALBERT DIVISION, CAPE PROVINCE.

By W. Versfeld, B.A., B.Sc.

A few years ago the writer was employed by a local syndicate to examine a locality where a considerable amount of gold had been discovered lying about in the surface soil, and where prospecting had been carried on for about two years. The conducting of this prospecting work had most unfortunately not been based on a correct understanding of the manner in which the gold occurred and what its origin was. Consequently much valuable time and still more valuable money had been wasted. This is mentioned to show why, since that time, very little has been done, the original shareholders being unwilling to put more money into the venture and new ones being difficult to find.

It is very many years since the first discovery of gold was made on the farm "Spreeuwfontein," in the Prince Albert Division—about 25 miles north-east of the village of Prince Albert. An ant-bear is credited with having unearthed the first nugget in an endeavour to unearth what was to him of far greater importance than all the gold in the world.

For many years the search for further nuggets has gone on with varying success, but no real effort has apparently been made to locate the position of the reef from which the gold has been derived. Instead of that numerous theories have been advanced to account for the presence of the gold.

All the gold so far found at Spreeuwfontein is alluvial, consisting of more or less water-worn particles, from dust to fairly sized nuggets. Subsequent discoveries were made on a farm called "Ganze Kraal," about ten miles to the east of Spreeuwfontein, at Hartebeest Fontein, about thirty miles to the east of Ganze Kraal, and at other localities between these places. At these spots a considerable amount of gold has been found in a thin layer of soil lying on the bed rock. Many nuggets were picked up on the very surface of the ground, some being many ounces in weight.

In addition to ordinary nuggets, specimens were found which threw a great deal of light on the origin of the gold. Two specimens are evidently portions of a *bona-fide* quartz reef, as each shows two sides of the reef. One is two inches thick and the other an inch and a half, but both are so abnormally rich that the discovery of the reef or reefs from which they were broken would be of tremendous importance to the Cape Province. These specimens are estimated to contain more than half their weight of gold—say from twelve to fifteen thousand ounces per ton.

The other specimens are exactly what one would expect to find produced by the wearing down of the first-mentioned pieces by the mechanical action of water. There are pieces similar to the above, but with a good deal of the quartz removed. The gold has in most cases actually filled a space in the centre of the reef, and when subsequently portions of the reef are broken off and some of the

quartz removed, the gold sticks out in flat, platey pieces, which eventually become bent over against the remaining quartz. This has led people to believe that the gold cannot be derived from a reef since it appears to have grown round the fragments of quartz, and we consequently hear of a theory being advanced that all the gold has been dissolved out of a certain bed of sandstone, which is stated to contain as much as 2 dwt. per ton, and re-crystallized from solution, in the form of nuggets, at the spots where the latter are now found. In support of this theory it is quoted that in some specimens distinct crystal faces are noticed.

A careful examination of the specimens found confirmed the writer's first opinion that they were reef gold. Every step in the formation of a waterworn nugget from a piece of rich reef is well illustrated. The fact that some of the gold shows crystal faces is easier of explanation in the case of reef gold than in that of nuggets crystallized in soil, for in reefs, especially such as are found in this locality, there is generally more space for crystals to develop than there would be in soil. In the latter case, too, the dissolving and recrystallizing would have to take place under conditions very similar to those existing at the present day, which are by no means favourable, at any rate for the dissolving of surface gold.

The geological formation at the Ganze Kraal locality is very simple. The bed rocks are shales and fine-grained sandstones belonging to the Beaufort Series. Saurian remains are fairly plentiful in the vicinity. These Beaufort Beds lie on the Ecca Beds, the basement conglomerate of which crops out many miles to the south at the Great Tygerberg. This range of hills is formed by an upheaval which has thrust the Witteberg Quartzites through the Ecca Series. Further south there is a similar, but much greater, upheaval, which has brought the Zwartberg Mountains into being.

From the village of Prince Albert, at the northern foot of the Zwartberg Range, there is a gradual increase of elevation from 2,100 feet to 4,400 feet above sea level, the latter being the elevation of Ganze Kraal. At this point there is a rather flat anticline, the axis of which, running east and west, is a little north of the spot where the best specimens of gold have been found.

The bed rock consists mostly of very fine-grained sandstone, merging on the one hand to a shale and on the other to an ordinary sandstone. A large number of perfect cubes of iron pyrites are met with, scattered through the rock. Near the surface they have been partly or completely oxidised to Limonite. Here and there small irregular masses of Calcite are found, evidently a secondary formation. At many localities calcareous nodules are found in the rock, sometimes in large quantities. The dip of the beds is not great, and the surface is gently undulating. At Hartebeest Fontein it is more hilly, and at Spreeuwfontein still more so, but the beds, though considerably denuded, are not much tilted.

Right through the gold belt a very large number of small quartz reefs are met with, all running approximately east and west. These reefs, or leaders, as they are locally termed, are of various widths, from mere threads up to one foot, and represent cracks formed parallel to the axis of the anticline. These cracks have been filled, or nearly filled with quartz, a marked feature of most

of the reefs being that the quartz is well crystallized, the crystals having had room to develop. In fact many of the reefs have still a vacant space in the centre. These spaces have subsequently been filled with clay that has been washed down from the surface soil, and as the latter contains particles of gold, these are found deep down in the reefs and have been the cause of considerable misconception. A shaft was sunk on such a reef, and it was stated that gold had been obtained 28 feet deep by panning. I took a sample personally at that depth, but instead of treating the whole sample as one, I separated the quartz from the clayey material and crushed and panned each separately, with the result that the former gave no result but the latter yielded some specks of gold.

Considering the conditions under which the gold is found, it would be strange if some were not washed down into open cracks. The surface soil at the Ganze Kraal locality is seldom more than one foot thick, except where it has accumulated in low places, and over a considerable area, practically every panful of earth is found to contain some gold, generally as small specks, but occasionally as nuggets.

A good deal of expense and unnecessary work has thus been carried on, including the sinking of several boreholes, which, however, have served the purpose of finding water in an otherwise nearly waterless locality. Two of the boreholes were tested with a steam pump, one for 24 and the other for 12 hours. Each gave a constant supply at the rate of 18,000 gallons a day without being exhausted. A considerable amount of water could be raised by means of Aermotors, wind frequently prevailing at this spot.

The writer is of opinion that by laying bare the bed rock by removing and washing a strip of soil, the outcrop of the parent reef, from which the rich samples were broken, will be discovered. Considering all the circumstances of the case, as studied on the spot, the most likely direction in which to look for the reef or reefs appears to be to the north of the spot where the best specimens were found on the farm Ganze Kraal. Failing a happy result, other directions should be tried. By taking a wide strip of soil wherever the washing pays and a narrow one where it does not, this work may yield a profit. In any case the gold found will repay part of the expenses. The distribution, appearance and degree of coarseness of the gold found will give valuable information as to the probable position of the reef, due allowance being made for topographical changes that may have taken place and consequent secondary concentration.

The finding of particles of gold, that are not waterworn, does not by any means prove that the parent reef is very near. The gold was originally protected by quartz, most of which had to be broken off during transportation, before the former could become waterworn. On examining apparently rough nuggets with a lens, most of them will be found to have their most prominent points somewhat worn. These would be the points that first became exposed as the quartz was gradually removed. The finding of long nuggets of rough gold with only the extreme points waterworn seems to prove that the nuggets were originally protected by quartz

during transportation, otherwise the middle parts would be worn more than the ends, since any rolling or sliding would take place on the shorter circumference.

The following facts are thus presented :—

(1) The gold found lying in the soil has been broken from some reef or reefs.

(2) The gold has been found at several localities forming a belt running approximately east and west for at least 40 miles.

(3) In the immediate neighbourhood are numbers of quartz reefs, also running east and west, and exactly resembling in size and the nature of the quartz those carrying the gold. None have been observed running in any other direction.

(4) The gold has been transported some unknown distance, as is evidenced by the worn edges.

(5) The general slope of the country is from the north.

It thus seems reasonable to assume that the reefs carrying the gold also run east and west, that the outcrop is to the north of the spot where the specimens were found, and that by following the course suggested of removing a strip of soil from the bed rock the outcrop will be found. This work can be carried out easily and rapidly. It is hardly possible that just where the reefs are intersected by the present surface of the rock, they should be quite without gold, though it would be too much to expect that the whole extent of reef should be as rich as the specimens found.

When money has been spent on a mining venture without success, it is very difficult to raise any more to carry on further operations, even when it is proved that the money had been wrongly used. This seems to be the case in the present instance, but it should be pointed out that this is a very different proposition from the usual mining venture, in which a mineral deposit is discovered and money is spent on proving whether it is payable or not. In this case there can be no question of the payability of the reef, nor about its existence. Locating it is all that is required.

There is a fortune waiting to be picked up by the man or syndicate willing to run some risk.

NITON.—In a paper by Dr. R. W. Gray and Sir William Ramsay, read before the Royal Society on January 12, the disintegration theory of Rutherford and Soddy received further confirmation by the announcement that, as a result of several determinations of its density, the atomic weight of the radium emanation—for which the authors propose the name of niton—was found to average 223. This agrees well with the view that radium (at. wt. 226.4), on changing into niton, loses one alpha particle (at. wt. 4). With regard to the name proposed by them, the authors point out the desirability of indicating, by similarity of name, that the gas belongs to the argon family. This is regarded as preferable to emphasising its radio-active relations. If the latter were to be indicated in the name, a similar principle would have to be applied to radium itself, which should then be named in some way that would indicate its derivation from uranium.

NOTES ON *CROTALARIA BURKEANA* AND OTHER LEGUMINOSE PLANTS CAUSING DISEASE IN STOCK.

By Joseph Burtt-Davy, F.L.S.

Crotalaria burkeana Benth., family Leguminosæ, is a native of the Transvaal and has for many years been recognised by farmers as the cause of a disease of stock known as Styfziekte; in fact the plant is known in the vernacular as the "Styfziekte bosje." It is also called "Klappers" from the character of the somewhat horny pods, in which the seeds rattle about. I called attention to the dangerous character of this plant, in my annual report for 1903-04 (**1**).

Symptoms.—The following reports have been furnished as to the symptoms produced by feeding on *Crotalaria.* "It is said to paralyse or stiffen the limbs of cattle" (**14**). "About five days after a beast has eaten this plant, it becomes very stiff in its joints and frequently is unable to stand. It is not fatal, however. A further development takes place in that the hoofs begin to grow, until at times they break off, making oxen almost useless for trekking for a long time" (**13**). "After eating these bushes cattle become almost too stiff to walk, and in many bad cases, after some time they are not able to stand on their legs. In all cases except when very mild, their hoofs grow long and make it very awkward for them to move about" (**15**). "The animals get perfectly stiff in their fore-legs, and, if not attended to, will lie down and are unable to rise again" (**16**). The cause of lameness is not stiffness of the joints, but laminitis, *i.e.,* inflammation of the sensitive laminae (**1**).

Stock Not Always Affected.—Mr. C. McG. Johnston reports that the Hoopstad district cattle appear to graze among *Crotalaria* without being in any way affected by it, year in and year out (**19**). (M. 1906). Mr. B. Burger, Middenin, Bultfontein, O.F.S., reports that the plant does not affect cattle that are used to it.

No Effect on Goats.—It is stated by farmers that this plant has no effect on goats (**20**). The same fact has been noted in the case of *Cytisus proliferus* in the Canary Islands (**6**).

Local Remedies.—Although they are often empirical, it is well to take note of local remedies, as they sometimes throw an indirect light on problems. "The only thing that I have noticed helps them a little is to outspan as soon as one sees that they are affected. I should be very pleased to get some remedy" (**15**). The South African farmer is fond of homœopathic remedies, and this disease is no exception to their rule that like cures like. One correspondent wrote that "as a cure the same shrub is taken and boiled in water, a sufficient quantity to fill a quart bottle is given and they are right in a few days." Another reported that a good remedy is to make the beast swim several times, after which it

gradually gets better. One tablespoonful each of turpentine, paraffin and raw linseed oil has also been recommended (18).

Feeding Tests.—Difficulty was experienced in securing enough material for a feeding test; when at length sufficient was obtained it was sent to Dr. Theiler; 6½ lb. of the dried plant was fed to four bastard sheep under the supervision of G. V. S. Johnston, in April, 1906, but no results were obtained. The material was somewhat mouldy, having been delayed in transit from the Free State. Mr. Johnston suggested the possibility that the toxic properties might have escaped during the process of evaporation, which reduced the weight of the parcel from 10 lb. to 6½ lb. In the case of *Crotalaria sagittalis,* however, the dry hay is equally liable to cause the disease. It seems possible that the bastard sheep is, like the goat, more or less immune to some toxins, as was suggested at the time by Stock Inspector Everitt.

Reports from farmers continued to reach me to the effect that this plant caused loss of stock. Owing to the fact that other species of *Crotalaria,* in other parts of the world, are known to cause death, I felt confident that there was some foundation for the suspicion under which our plant was held by the Boers. I, therefore, arranged to have a further test made, but difficulty was again experienced in securing enough material. In April, 1910, however, about 12 lb. was collected by Mr. W. F. Williams, Vogels Rand, Ventersburg Road, in the Free State, and sent to Dr. Theiler. This was fed to an animal, but without result, which seems to indicate that there is a loss of toxicity in the process of drying, but it may have been that the quantity fed was insufficient and the feeding not continued for a sufficient period.

In the meantime, however, the Government Veterinary Surgeons at Zeerust and Barberton, working under Dr. Theiler's direction, had succeeded in producing the disease Styfziekte by feeding animals with *Crotalaria burkeana.* Specimens of the plant being fed were submitted to me from time to time, for identification. It having been proved that the plant is the cause of the disease, some account of its habit of growth and distribution may be of use to Veterinary Surgeons and farmers.

Description of the Genus.—The genus *Crotalaria* of Linnaeus, belongs to the Family Leguminosæ, Sub-family Papilionaceae and the Tribe Genisteae. It differs from other South African genera of this tribe by the usually stipulate leaves which are either simple or palmately compound, the sharply rostrate carina, very inflated legume, and racemose or scattered (not umbellate) flowers. It is described as follows :—Calyx sub-bilabiate, the upper lip bifid, the lower trifid. Vexillum large, cordate; carina falcate-acuminate. Stamens monadelphous. Ovary 2- or many-ovuled; style elongate, knee-bent, often laterally pubescent. Legume turgid, with very convex valves, sessile or stipulate, few or many-seeded.

The Crotalarias are either herbs or shrubs, and are common throughout the tropics and sub-tropics of both hemispheres. Leaves either simple or palmately 3—5—7—foliolate, commonly stipulate; bracts and stipules sometimes wanting. Flowers either racemose or sub-solitary, but not umbellate. Some species of

Lotononis, especially in the section *Oxydium* approach *Crotalaria* in the form of the corolla, but differ by their umbellate inflorescence and unswollen pod. In other Lotononides, when the pod is more turgid, the carina is not sharp.

Twenty-four species of *Crotalaria* are described in the *Flora Capensis* (1862), of which seven occur in the Transvaal. Four not described in the *Flora Capensis* species are found in the Transvaal, of which two belong to the Tropical African flora.

Description of C. burkeana.—This species belongs to the Section Racemosae, having leaves digitately 3 to 5-foliolate, and racemes mostly terminal and densely or laxly many-flowered. It differs from other species of this Section by the small, subulate stipules; narrow lanceolate, acute leaflets; long calyx-lobes; and densely hispid branches and petioles; variety *sparsipila* is, however, much less hairy.

C. Burkeana Benth. — Herbaceous or suffruticose, erect; branches, petioles and racemes densely hispid, with long, spreading, rusty hairs; stipules linear-subulate; leaflets 3—5, linear-lanceolate, acute, glabrous above, pilose beneath; racemes terminal, lax, several-flowered; bracteoles lanceolate; calyx deeply cut, its segments lanceolate, nearly as long as the corolla; legume sub-sessile, oblong, very hairy.

var. β. *sparsipila* Harv.—Much less hairy, with larger petioles, leaflets and racemes.

A perennial, herbaceous plant, one to two feet high, woody at base, with many herbaceous, slightly branched stems, freely covered with stiff, harsh, rusty brown hairs. Pubescence copious. Petioles 1—1½ inches long, leaflets as long, often 5 together, 1 to 2 lines wide, acute at each end. Racemes pedunculate, terminal, 10—15—flowered. Flowers pea-shaped, yellowish with purplish brown veining, about ¾ inch long. Legumes 1½ inches long. var. β is a more luxuriant and less hairy form, and probably grew in richer, alluvial soil.

Type locality.—The type locality for *Crotalaria burkeana,* is the Magaliesberg, at the Aapies River, doubtless on the north side of the Wonderboompoort, where it was collected by Burke and Zeyher about 1832. The type of variety *sparsipila* was collected in Zululand, by Miss Owen.

Distribution.—In the Transvaal *Crotalaria burkeana* is most abundant in the south-western region, including the districts of Bloemhof, Wolmaransstad, Western Potchefstroom, Marico and Rustenburg. It has also been collected in the Pretoria, Zoutpansberg and Barberton districts, and may be expected in the Lichtenburg, Waterberg, Middelburg and Lydenburg districts.

In the Orange Free State it occurs in the Boshof, Hoopstad, Kroonstad, Heilbron and Winburg districts.

In the Cape Province it occurs in Griqualand West, in the districts of Barkly West and Herbert.

In Natal it is recorded for Durban County, and there is a solitary record from Zululand.

Localities.—The following localities are recorded, and mostly represented by specimens in the various herbaria. I am indebted

to Dr. Bolus, Mr. Medley Wood, Mrs. Leendertz-Pott, Dr. Schönland and Prof. Pearson for lists of the specimens preserved in the herbaria under their respective controls.

BARBERTON DISTRICT.

Macsvale 24/1/07. W. P. Macpherson, in T.D.A. herb. 3298 letter 3715/B.161/84.

Barberton July to September E. E. Galpin 405 in herb. Bolus; Thorncroft in T. M. Herb; Bolus.

Near Barberton, January 4th, 1909, G. V. S. Turnbull, in T. D. A. herb.

BARKLY WEST DISTRICT.

Fourteen Streams (reported).

BLOEMHOF DISTRICT.

Kromellenboog, by roadside, rare, "said to poison stock December 2nd, 1904." Burtt-Davy 1494, in T. D. A. herb.

Elsendale, Christiana (seeds ripe), April 19th, 1907. H. G. Mundy in T. D. A. herb 4324.

Elsendale, Christiana, in seed, November, 1908. Burtt-Davy 5542.

Christiana Town Lands, May, 1910. Burtt-Davy 8068.

Holwater, 1909, teste F. J. Few.

Bloemhof, February 15th, 1907. "Causing Styf-ziekte." C. C. Campbell in T. D. A. Herb. 3348.

Vecht Vallei, P.O. Abels Kop, Schweizer Reneke, teste F. O. Mallett in litt. May 13th, 1910.

BLOEMFONTEIN DISTRICT.

Specimen from O.F.S. Department of Agriculture, locality not stated, February 24th, 1906. T. D. A. herb. 1689.

BOSHOF DISTRICT.

Reported as occurring on several farms bordering on the Vaal River.

GRIQUALAND WEST DIVISION.

Between the Vaal and Kuruman, July, Cruikshank in herb. Bolus 2516.

HEILBRON DISTRICT.

Parys; W. R. Dewar, ex Botha No. 3, March 8th, 1905.

HERBERT DISTRICT.

Douglas; Miss Orpen in herb. Bolus.

HOOPSTAD DISTRICT.

Mr. C. McG. Johnston, of the Orange Free State Department of Agriculture, reported that on several farms in the Hoopstad district he had seen a fair quantity of *Crotalaria burkeana.*

Specimens were received from Stock Inspector Everitt, Hoopstad, March 27th, 1906 (farm not stated).

Willow Dam, Bultfontein, March, 1904, in seed, A. W. J. Atkinson, in T. D. A. herb. 77.

Middenin, Bultfontein, 1910. B. Burger in litt.

KROONSTAD DISTRICT.

Gelykvlakte, via Klerksdorp, 1904. B. J. Marshall.

MARICO DISTRICT.

Near Zeerust, G. V. S. Evans.

NATAL.

Durban, March, Medley-Wood 559; 913 in herb. Bolus.

POTCHEFSTROOM DISTRICT.

Machavie, ripe pods, February 9th, 1904. Burtt-Davy 1485.

Reported as common near Klerksdorp.

Potchefstroom, October, McLea in herb. Bolus.

PRETORIA DISTRICT.

Magaliesberg at the Aapies River, 1832? Burke & Zeyher (type).

RUSTENBURG DISTRICT.

Kosterfontein, "on a single ironstone kopje only." Specimens sent by a correspondent, 1904.

SWAZIELAND.

Bremersdorp, Bolus 11,784 in herb. Bolus.

WINBURG DISTRICT.

Vogelsrand, Ventersburg Road, March 12th, 1910. W. F. Williams in T. D. A. herb. 5841.

WOLMARANSSTAD DISTRICT.

Said to be common in the district. G. V. S. Dale reports a farm on which about 20 cases of Crotalaria poisoning existed in June, 1910.

Leeuwdoorns, S. J. Hyde, February 9th, 1909 (plants in seed; seeds sown at Skinner's Court).

ZOUTPANSBERG DISTRICT.

Tzaneen, August, 1905, Pole Evans in T. D. A. herb. 4013.

Pietersburg, Schlechter in T. M. H. and herb. Bolus.

Frischgewacht. Ysterberg, Mrs. Leendertz-Pott in T. M. H.

Near Pietersburg cir. 4,000 ft., February, 1904, Bolus in N. G. herb.

Vaalboschfontein, 4,400 ft., January, Schlechter 4234 in N. G. herb (district not stated, probably in Zoutpansberg).

ZULULAND.

Miss Owen, teste *Flora Capensis.*

Soils.—Crotalaria burkeana is most common in sandy soils, and is often to be found in silt along the roadside. G. V. S. Dale, of Potchefstroom, reports that in some parts of the western portion of his district it is especially common on old lands. It is found that even if it exists in the unbroken veld in such small quantity as to be harmless, as soon as the land is cultivated, and maize or kaffir corn planted, the *Crotalaria* makes its appearance along with them.

Season.—Growth begins about October, or with the spring rains, according to locality. At Leeuwdoorns it does not appear till December (Hyde). The plant is said to be most poisonous when the pods have developed, which is usually about the end of January or in February (**13**). In the Barberton district cattle do not appear to be affected until about January (**17**). It is cut to the ground by severe frost, and being brittle, soon breaks up and disappears. By the end of May it is often difficult to find any, even in localities where it is usually abundant. In some years it has disappeared by the end of March. The Assistant Resident Magistrate, Klerksdorp, writing under date January 20th, 1904, reported that the plant was said to be at its worst about that time.

OTHER PLANTS CAUSING NEURITIC TROUBLES.

The late Professor MacOwan, Cape Government Botanist, came to the conclusion that there had been a serious confusion in the farmer's recognition of the disease, and that a large number of cases of reputed styfziekte have been nothing more than tympanitis, that is "opblaas" or "hoven." The real styfziekte or t'nenta, he points out, is certainly an acute form of neuritis, and is attended by distinct lesions of the terminal portions of the nerve structures of the extremities. Here, again, there appears to have been some confusion between true neuritic styfziekte and "lamziekte," which latter Prof. MacOwan considered to arise from the absence of sufficient calcic phosphate in the food to properly solidify the bones (**6**). It is interesting to note that the general distribution of the disease called gal-lamziekte synchronises with the region of greatest abundance of *Crotalaria burkeana.* But it should not be overlooked that *Crotalaria* extends farther east and north than gal-lamziekte is known to occur, and that *Crotalaria* does not appear to grow in some parts of the Cape Province where that disease occurs. Other species of *Crotalaria* are likely to occur there, however. Mr. B. Burger notes that his stock are not troubled with lamziekte as regularly as with styfziekte; some years the former is severe, and in others not so bad. Moreover,

lamziekte generally results in death, while animals usually recover from styfziekte.

MacOwan pointed out that various forms of this neuritis occur in different countries, but that their correlation does not admit of doubt. The symptoms show small differences such as are to be expected when the species and genera of the plants eaten are not exactly the same.

Crotalaria sagittalis L. ("RATTLE-BOX").

In the Eastern and Central United States this plant is known to be poisonous to stock, producing a disease called "crotalism," or "Missouri bottom disease," because of the prevalence of the plant along the Missouri river bottoms of Western Iowa. The plant is poisonous, not only green, but also in dried hay.

Poisonous principle.—An unnamed alkaloid has been isolated from the seeds by Dr. Power, but Chesnut states that the poisonous principle is unknown, and that it occurs both in the leaves and the seeds. Horses and sometimes cattle are killed by eating grass or meadow hay in which the plant is mixed, but they are not poisoned so often by eating the plant in the field. Dr. Stalker, of Iowa, in 1884, while investigating the cause of bottom disease," then prevalent among horses in Iowa, was led to believe that it was mostly, if not altogether, due to this plant. Extracts were prepared which, when fed to young horses, produced analogous symptoms and death. The pronounced symptoms from a moderate dose were great stupor and loud, heavy breathing. A larger dose caused death in one and one-half hours. Small doses repeated daily induced the characteristic stupor on the fifth day, and death on the thirteenth (3).

Symptoms.—As generally described from accidental cases, the symptoms are much more prolonged, death resulting only after several weeks or months. There is a general decline of vigour, and a gradual loss of flesh, as observed in the case of loco, with which this plant is closely related. The rattle-box does not, however, appear so often to produce the craziness characteristic of loco.

Antidote.—No antidote has been suggested, but Dr. Stalker states that, provided the animals are given a proper and nutritious diet, they will be greatly benefitted by daily doses of 2 ounces of Epsom salts, with 2 drachms of sulphate of iron and 1 drachm of nux vomica.

Eradication.—Chesnut recommends burning the veld at the time of the seeding of the *Crotalaria*, which—he claims—will materially reduce the percentage in the veld hay cut the following season (3).

Crotalaria alata Hamilt.,

A native of India; is suspected of being poisonous to stock in Queensland.

Crotalaria Mitchellii Benth. ("YELLOW DARLING PEA").

A native of South Australia, New South Wales, and Queensland: is supposed to produce the same effects on cattle as Swainsona (10).

Swainsona galegifolia R.Br. ("DARLING PEA") "INDIGO."

In Australia this plant is well-known to be poisonous to stock. Most of the cases of poisoning by it are said to occur in the dry season, when stock are especially attracted by green and succulent foliage, and are more likely to gorge themselves upon a single species which remains green, if found in fair abundance.

Physiological action.—Prof. Martin has investigated the action of *Swainsona galegifolia* on sheep, and finds that its effects are similar to those produced by slow poisoning with alcohol and certain toxic proteids, resulting in peripheral neuritis and degeneration of the nerve endings, accompanied by a loss of muscular control. The action is a slow one, four to six weeks being required to produce serious symptoms. If at once put on a proper diet recovery takes place, but not if paralytic symptoms have supervened. Young lambs probably respond more rapidly to the poison; when the symptoms are fully established there is no remedy (**5**). Experiments on frogs indicated that Swainsona possessed very powerful sudorific properties, reducing them in a few hours to mere skeletons (**11**).

Bailey describes the effect on sheep eating the plant as follows: They separate from the flock, wander about listlessly, and are known to the shepherds as "pea eaters" or "indigo eaters." When once a sheep takes to eating it, it seldom or never fattens, and may be said to be lost to its owners. In 1873 a Mr. Charles Thorn tested this plant on a lamb which had become an "indigo eater"; it was placed in a small paddock, where it refused to eat grass; Mr. Thorn collected a quantity of the Indigo plant, which it ate greedily, following him all over the paddock and eating it out of his hand. Horses which had been feeding on Swainsona were exceptionally difficult to catch; their eyes were staring out of their heads, and they were prancing against trees and stumps. The second day two out of nine died and five of the rest had to be left behind. When driven they would suddenly stop, turn round and round, and keep throwing up their heads as if they had been hit under the jaw; they would then fall, lie down for a while, rise and repeat the performance (**11**).

LOCO WEEDS.

In California, Colorado and other Western States of America, a neuritic disease, ending in hallucinations and death, is produced by eating several species of the Leguminose genera *Astragalus* and *Oxytropis*. In Texas, *Sophora secundiflora*, also a Legume, is the cause of "locoism."

Lessertia annularis Benth. ("T'NENTA").

Prof. MacOwan pointed out that this Leguminose plant, when in full bearing of its crop of pods and ripening seeds, was a cause of true neuritic styfziekte in the Cape Province. A lesser amount of suspicion, he adds, rests upon several common species of Indigofera and Tephrosia (**6**).

Melolobium candicans Eckl. and Zeyher.

This plant was also reported by Prof. MacOwan, as suspected at the Cape, of causing t'nenta poisoning in small stock (**6**).

Cystisus proliferus Linn. f. ("TAGASASTE").

If eaten when in pod, this plant is said to intoxicate horses (**6**).

Lathyrus sativus ("MUTTAR").

The dried peas of this plant have been known to poison a whole stud of omnibus horses, the symptoms being analogous with the forms of neuritis already mentioned (**6** and **8**). A disease called "lathyrism" appeared among Russian peasants in 1891, after feeding on bread made of the muttar pea, when wheaten flour was unobtainable (**6**). Church states that the paralysis induced in horses, bullocks, as well as in man, by the free use of these seeds is beyond dispute (**12**).

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15. MARSHALL, B. J., *in litt.*
16. A correspondent at Kosterfontein, Rustenburg District.
17. TURNBULL, G. V. S., *in litt.*
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19. JOHNSTON, C. McG., *in litt.*, 734 of April 23, 1906.
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TRANSACTIONS OF SOCIETIES.

South African Institute of Engineers.—Saturday, February 11th: J. A. Vaughan, President, in the chair.—"Borehole Deflections": J. S. **Curtis**.—The author described observations and experiments which strengthened him in conclusions previously published, to the effect that deflection of bore-holes is due to the magnetization of the drill rods resulting from their revolution in the terrestrial magnetic field.

South African Society of Civil Engineers.—Wednesday, March 8th: Col. G. T. Nicholson, M.I.C.E., President in the chair.—Presidential address: Col. G. T. **Nicholson**.—The problems connected with dock engineering were dealt with and the relative merits of hydraulic and electric equipment were discussed, the latter being considered more economical.

Chemical, Metallurgical and Mining Society of South Africa.—Saturday, February 18: Dr. J. Moir, M.A., F.C.S., President, in the chair.—"Profit per fathom": R. E. **Sawyer**. Notes supplementary to the arguments put forward by Marriott in favour of his fathomage system in the *S.A. Mining Journal* of March, 1910.—"Practical notes on coal": M. **Dodd**. A discusssion of the composition, classification, uses of different sorts, and selection of coal in connection with mining operations.—"Faulting phenomena in Rand Mines": G. H. **Beatty**. An exposition of and comment upon certain examples of complicated faulting that had come under the author's notice.

ADDRESSES WANTED.

The Assistant General Secretary (P.O. Box 1497, Cape Town) would be glad to receive the correct addresses of the following members, whose last known addresses are given below:—

Bay, Dr. B., P.O. Box 5513, Johannesburg.
Boulton, H. C., c/o Messrs. Pauling & Co., Ltd., Broken Hill, Rhodesia.
Brown, W. B., c/o Engineer in Chief, S.A. Railways, Cape Town.
Champion, Ivor Edward, P.O. Roberts Heights, Pretoria.
Dickie, Andrew, 475, Currie Road, Durban, Natal.
Leech. Dr. J. R.. 4th Avenue. Melville. Johannesburg.
Macfarlane, Donald, M.I.C.E., H.M. Naval Dockyard, Simonstown, Cape.
Mirrlees, W. J., 9, London Chambers, Durban.
Nichol, Thomas Thompson, P.O. Box 34, Springs, Transvaal.
Nicholas, W. H., Durban High School, Durban, Natal.
Nicholson, J. Greg, Leliefontein, Government School. P.O. Carolina, Transvaal.
Pakes, Dr. A. E. H., P.O. Box 5, Belfast, Transvaal.
Petersen, H. T., P.O. Box 5, Cleveland, Transvaal.
Preston, James, 89, Arnold Road, Observatory, near Cape Town,
Southwell, Miss Jessie, 270, Visagie St., Pretoria.
Van Oordt, J. F. Harrismith, O.F.S.

SOME NOTES IN REFERENCE TO THE MACHINERY IN USE IN THE TRANSVAAL SHORTLY AFTER THE RETROCESSION OF THE COUNTRY TO THE BRITISH.

By Harry W. Miller, A.M.I.C.E.

When the writer entered the Transvaal at the beginning of 1883, there was very little mining carried on except some alluvial washing at Pilgrim's Rest, for which no machinery was required. Some of the quartz outcrops in that district were being investigated, and a few mills were designed to deal with these reefs, and later on were built and for a brief period worked. In that year there were two manufacturing concerns under construction, the Hatherley Distillery and the Gunpowder Works. At the former, steam was supplied for distillation and power by two compound boilers made in Germany, the lower portion being a cylindrical boiler with a large flue tube, surmounted by a similar boiler with a number of small tubes running through it. The fuel obtainable then was only inferior grade bush timber, so to obtain a sufficient grate area, a furnace or fire box was built outside of, and adjacent to, the flue of the lower boiler, and the result was a considerable loss of heat by radiation, and, at a later period, when coal was procurable, the furnaces were altered to permit of firing in the flue tube at the suggestion of the writer, with resultant economy. The driving motor was a horizontal engine of about 30 brake h.p. This Company was the possessor of the only lathe and drilling machine operated by power at that time in the Transvaal. It is interesting to remark here that the lathe was largely employed turning down shells for a 7-pounder cannon that the Boers had captured from the British, and which formed a large proportion of their then supply of artillery. The remaining plant of this company consisted of a portable Robey engine, that drove the circular saw employed for cutting up the bush timber for fuel, and a Robey portable pumping engine, which was seldom used.

The Gunpowder Works was equipped with a boiler of the Elephant type, made by Halls of Dartford, a type of boiler much affected in explosive works on account of its safety from explosion when the feed water got below the normal level. This class of boiler is obsolete to-day, as it is very troublesome to set, and, if any bricks become dislodged in the arch over the lower tubes, its draught efficiency is much impaired. It was, however, well adapted for the inferior fuel we had to use then, having a large grate area, and even when coal was obtainable later, it gave good results with the inferior coal first mined in the Transvaal. It supplied steam at a pressure of 60 lbs. to a 14in. by 24in. horizontal engine, developing about 45 I.H.P. The other steam power on the property consisted of a 10 Nom. H.P. Hornsby semi-portable engine and boiler with the engine mounted on the top of the boiler. This engine also drove the circular saw for

cutting up the fuel for the boilers. Although wood fuel was cheap, the expense of cutting it into suitable lengths with the circular saw was so great, and the whole business was such a worry to the steam user, that the search for coal was encouraged; and later when it was found, in spite of the heavy costs of ox-wagon transport, and the low calorific value of the coal, it was eagerly purchased by the management of the two factories, at that time the only consumers of coal in the Transvaal.

Later on a few small isolated steam plants came into existence, a mill at Franzpoort, not far distant from the two factories, being operated by a 4 Nom. H.P. Gyppswyk engine and vertical boiler by Turners, of Ipswich. A small Ether ice machine was installed at the European Hotel in Pretoria at this time (1884), and to the best of my recollection this was the only refrigerating machine in the Transvaal. During the middle of 1884, developments on the farm Paardeplaats, near Lydenburg, were pushed on, and in the early part of 1885 a 15-stamp mill was erected. This mill was made by Mitcheson, of Durban, and was driven by a small Under type compound engine with loco. boiler, made by Marshall's. This mine proved a failure, and the engine and boiler were subsequently bought by R. White, the chief storekeeper in Middelburg, and erected under the supervision of the writer, to drive three pairs of mill stones for grinding wheat and mealies. At this time coal was beginning to be worked in a feeble manner in the Middelburg district, 1886-1887.

In the latter portion of 1884, a coal mine was secured, conjointly by the Hatherley Distillery and the Gunpowder Factory, for supplying the wants of these factories. This mine was located at Bronkhorstspruit, and was worked by a short incline from the surface to the seam, which was only about 30 feet deep below the grass roots. The coal was of a very inferior quality, and to-day would not command a sale at any price. No machinery, save a small hand pump, was used or required. This was, I believe, the first systematic coal mining in the Transvaal.

At the latter end of 1885, Harry Struben erected a 5-stamp Sandycroft mill, driven by a 10 Nom. H.P. Ransome portable engine, on his farm Wilgespruit, and on February 20th, 1886, he brought in 62 oz. of gold out of 200 tons crushed. About this time Erasmus and others bought and erected a 5-stamp Sandycroft mill, driven by a Vortex turbine, made by Gilbert Gilkes, of Kendal. Simultaneously with these developments, a small syndicate was opening up a very promising quartz reef on the farm Kromdraai, and the writer built and erected for them an overshot water wheel 22 feet diameter by 3 feet width of buckets. This was constructed locally, of South African timber, and communicated motion to the countershaft driving the battery, by spur gearing, made in Natal by Mitcheson. The mill was a 5-stamp Sandycroft of 750 lb. stamps, and, like all the others put up at this time, possessed neither feeders nor stone crushers, all this work being done by hand. A dam was built in the creek, about half a mile distant, giving the necesary fall to the wheel, and the supply of water was just enough to give the stamps about 65 to 70 drops per minute of 6 inches. The mill worked very

cheaply, as can be well imagined, but its duty was not very high. None of these mills remained at work for a very extended period; indeed the result of their combined gross operations would probably be effected in one month with one of the smaller size mills at present in use. At the end of 1886, a man named Rasch put up a 5-stamp Sandycroft mill, driven by a 22 feet diameter iron overshot water wheel, with buckets 3ft. 6in. wide, on the banks of the Crocodile River, near Pretoria, to work some promising-looking quartz veins in the range of hills to the north of Pretoria; but this plant, like most of the others, only ran for a limited period.

In these days the only fuel available on the Rand was bush timber, and this cost considerably; consequently it was the aim to get a mill site near a river or spruit to procure the necessary power to operate the machinery. But towards the middle of 1887, the discoveries on the Witwatersrand became so promising that mills driven by steam power began to be more common. These mills were built by Sandycroft and had stamps 750 lbs. weight. No ore feeders were used, nor stone crushers. At this period the only American-made mill was at Lisbon-Berlyn, and out of 60 stamps supplied only 10 were erected on this mine. The mill was a knee-framed battery of 920 lb. stamps, and was fitted with the Hendy ore feeder. The ore in this case was broken preliminarily with Blake crushers. The chief defect in this mill was that the mortars were made in sections for convenience of transport, these being in five sections, tied together with longitudinal bolts, the housings being made of cast iron on the front and back and steel plates on the ends. The housings were secured to flanges on the cast iron bottoms by rivets and bolts. This mill was driven by a Pelton wheel under a head of 1,000 feet. The adjacent mine, Graskop, was equipped with 20 stamps of 850 lbs. The mill was made by Sandycroft, but the framework was of the American type, and the mill was fitted with automatic feeders and stone breakers. This was also a water power driven mill. During 1887, Knights Company, now known as the Witwatersrand G.M. Company, entered into a contract with Robey & Co. for a complete mill of 100 stamps, with Jordan's concentrators. This mill was built in four groups of 25 stamps on one cam shaft, the cam shafts being made in two sections, 15 stamps on one section and 10 on another, both coupled with solid flanged couplings and turned bolts. Each group of 25 stamps was driven from a flywheel and 20in. belt on the extreme ends of the crank shafts of a 2-coupled simple Robey non-condensing engine, with cylinders 16in. by 32in. Steam was supplied by four Robey loco. type boilers of 25 Nom. H.P. Nearly all the mortar boxes broke within a few months' time, and were replaced by Sandycroft mortars. The Jordan concentrators were a failure from the start. Very little crushing, comparatively speaking, was done by this mill, that boasted a good mill site on the side of the hill, an unusual thing then.

The first American mills erected on the Witwatersrand Gold Fields were the 20-stamp mill at the Bantjes, originally ordered

for the Kimberley Imperial Mine at Barberton, but which was stopped at the Rand whilst *en route* to Barberton; the 30-stamp mill for the Paarl Pretoria G.M. Company, and the 10-stamp mill for the Langlaagte United. These mills were all of 850lb. stamps, and the two first-named had Corliss engines and return tubular under-fired boilers. The smaller mill was driven by a slide valve engine, with a return tabular under-fired boiler. They were supplied with Blake ore crushers, and were noticeable as being the first mills equipped with Frue vanner concentrators, which for a considerable period was regarded as the standard machine for this purpose on the fields, until the extended developments of the cyanide process demonstrated that close concentration was neither necessary nor desirable. Just about this period, the writer became an advocate of condensing being applied to the mill engines, as the quantity of water required for the plates is the amount needed for surface condensation of the steam required to drive the stamps. I met with the most cordial support from Mr. Hennen Jennings in this connection, and when the Robinson Company decided in 1890 to lay down a large compressor and rock drills, a surface condenser was supplied for use with this plant. Attention was now being turned to these American mills, and when the Langlaagte Estate Company ordered 60 stamps for their mine, and the Robinson Company 40 stamps for theirs in 1888, and their subsequent behaviour was satisfactory, the Sandycroft people found they had a formidable competitor in the field, and orders began to be more equally distributed between these two firms at this time. These two mills were singular in being the first gravitation quartz mills erected on the Rand, the ore going from the mine into the top of the mill above the crusher floors and bins, and gravitating through, until finally it left the launders as pulp. It then went to waste on the tailings dumps, as little attention was then given to these residues. About this time the Corliss engine became popular on account of its speedy running under variable loads, and many mills were operated with them, nearly all the American-built mills being so fitted. All these engines were single cylinder non-condensing, the exhaust steam being utilised to heat the feed water. At this time the loco. type of boiler began to go out of fashion, the larger powers demanded rendering this type unsuitable for transport on wagons, whereas the return tabular boiler, being a plain cylinder, was easily handled, and even if transport riders were compelled to off-load on the road when stuck in bad places, it was an easy matter to parbuckle one of these boilers back on to the wagon.

The return tubular boiler did not call for a very high quality of bricks for its seating, which was another advantage, and moreover the grate could be made of large area, which was necessary for the very inferior fuel used in those days. The bricks then made were of the class known as "slope," and were hand-made and burnt in clamps with wood for fuel. They were fairly cheap, if not of very good quality. The size of boiler of this type then generally used was 54in. diameter by 16ft. 0in. long, capable of developing from 80 to 90 H.P., and the steam pressure was 80 lbs. maximum. As the fields progressed, larger boilers were used

with higher pressures, and compound engines were employed, with very often surface condensers fitted.

About the end of 1889 attention began to be turned to machine drills, and several small plants were fitted. The Robinson Company were the first people to lead the way in any extensive manner in this direction, and under Mr. Spencer's management a fine 20-drill plant was installed, and both Ingersoll and Rand drills were used under the supervision of a competent drill foreman, who came from America specially for this purpose. This marked a very important epoch on the fields, and shortly afterwards the Langlaagte Estate Company followed suit in a similar manner. The writer believes he was the first on the Rand to employ compressed air underground for the use of hauling and pumping engines, and a rapid increase in the prosperous condition of the Langlaagte Estate Mine is distinctly due to the extended use of compressed air.

In the middle of 1890 the prospects of the Langlaagte Estate Mine were so good, the directors ordered a complete mill of 120 stamps with compound condensing engines of 500 H.P., condensers, boilers, pumps, pipe lines, ore cars for mine and surface, etc., in fact a most complete equipment. This gave the needed impetus for large crushing outfits, which, in a comparatively short time, became common. Block B built an 80-stamp mill, Robinson increased to 60, Ferreira put up 40, and many other mines followed suit.

Prior to September, 1889, the Langlaagte Estate had the largest mill, 60 stamps, in operation. In this month the Jumpers had 70 stamps at work, but the Langlaagte Estate ran their 10-stamp mill as well, so the number of stamps in operation on both mines was the same. In January, 1890, the Jumpers had 100 stamps running. In October, 1890, the Simmer and Jack had 75 stamps at work, in November 90 stamps, and in December 80 stamps. Before the other mines had increased their stamping capacity, the Langlaagte Estate had started their 120-stamp mill in March, 1892, and this mill was increased to 160 stamps in September, 1893, and it remained the largest reduction plant on the Witwatersrand Gold Fields until the New Primrose increased their mill to 160 stamps in January, 1895. In July, 1896, the City and Suburban increased their mill to 160 stamps, but in January, 1897, the Langlaagte Estate added 40 stamps, making a total of 200 stamps, thus retaining the lead in this respect. In December, 1897, the Simmer and Jack took the lead with their 240-stamp mill, of which 200 stamps were working in December and the full mill of 240 stamps in February, 1898. This mill was further increased to 280 stamps during 1898.

The 120-stamp mill of the Langlaagte Estate was very much improved in its equipment, compared to the mills previously erected. The suspended Challenge ore feeder was used here for the first time in Africa, and the stamp driving pulleys were fitted with friction clutches of the rim type. Leather link belts were used for the stamps; there was no masonry employed in the construction of the mill, nothing but timber framework being adopted; the engines were compound condensing, and the mill

line shafting and crusher countershafting was driven by ropes from a large grooved flywheel on the engine crank shaft. The ore was hoisted into the top of the mill by a double cage-way, the cages being wound up and down by a double-cylinder winding engine of the usual construction.

Up to this period most of the mills were illuminated at night by oil lamps. An electric lighting plant had been installed at the Langlaagte Estate, with accumulators fitted, but it was not a success. The dynamo was subsequently made to operate six lamps in series, but when the new mill of 120 stamps was built a complete electric lighting installation was included. The Jumpers and Simmer and Jack had, however, prior to this, been excellently equipped in this respect, and it then became the accepted means of illumination for the mills and surface plant generally. It is interesting to recall the prices paid for incandescent lamps at that time: for 16 c.p. 60 volt lamps, 9s. each; 16 c.p. 100 volt lamps, 6s. 6d. each, when bought in large quantities; 200 c.p. Sunbeam lamps, 37s. 6d. each. These lamps were of the Swan-Edison make. Up to the end of 1890, although the majority of the mills were placed more or less in the beds of the creeks to avoid the expense of pumping the water needed for the plates and concentrators, little trouble had been experienced with the banking up of the tailings. This trouble now began to present itself, and mechanical means had to be resorted to for relief. At the Langlaagte Estate, the writer successfully employed centrifugal pumps, with mechanical stirring of the pulp in the sumps, and by these means tailings were elevated a height of from 23 to 25 feet at a cost of 2d. per ton, which included all charges, fuel, labour maintenance and depreciation. At the Durban Roodepoort and the Village Main Reef Mines, plunger pumps were successfully employed for the same work; but later on the tailings wheel came into vogue, the Glencairn Mine being, I think, the first to adopt this system of raising tailings, which remains a favourite means of handling residues until this day. It is, however, noteworthy that the system of elevating tailings by means of centrifugal pumps, introduced by the writer 20 years ago, is again beginning to attract notice, and seems likely to displace entirely the cumbersome tailings wheel.

At this time diamond boring had demonstrated the existence of the conglomerate series at great depths. The Village Main Reef Company had bored very successfully in 1890, and the Henry Nourse Deep followed suit, and at a depth of 605 feet the South Reef was intersected, the reef assaying over 6 ounces for 3 feet 6 inches thick. The Main Reef Leader was cut at 658 feet, assaying 2 ounces for 5 inches thickness, and the Main Reef itself showed well. These results gave a tremendous impetus to the exploitation of the lower rows of claims, and progress from this time was very rapid. More advanced methods of dealing with the mines were continually being adopted, and the introduction of the use of electrical energy to transmit power from a central power station on the property was the forerunner of the vast schemes now prevalent for the supply of electrical energy for all purposes

and to any extent the customer demands. It is somewhat gratifying to remember that the very complete electrical transmission installation on the Princess Estate Mine at Roodepoort, which the writer had the privilege of designing in conjunction with the late R. Oliver Drummond, followed by a similar installation at the City and Suburban Company, designed also by Mr. Oliver Drummond, have proved to be the modest forerunners of the gigantic plants now becoming quite common in South Africa.

From this time forward the development of the Witwatersrand Gold Fields proceeded by leaps and bounds. The comparatively insignificant geared winding engines at the shafts gave place to direct winders of large size and considerable hoisting capacity. The metallurgical chemists had solved in the most satisfactory manner the problems connected with the extraction of the gold from the ore, and results of 87 to 90 per cent. extraction were becoming common, and it may truly be said that the Transvaal Gold Fields had embarked on the prosperous career that has made them the wonder of the world. What has been done subsequently is too fresh in our recollection to be recapitulated here, but I trust that these few remarks on the earlier methods and apparatus used for the exploitation of the gold mines in this country may prove of interest.

BRITISH ASSOCIATION.—The 1911 Session of the British Association for the Advancement of Science will begin at Portsmouth on the 30th August, under the Presidency of Sir William Ramsay, K.C.B., F.R.S. The sectional presidents will be as follows: Mathematics and Physics, Prof. H. H. Turner; Chemistry, Prof. J. Walker; Geology, A. Harker, M.A., F.R.S.; Geography, Col. C. F. Close, R.E.; Economics and Statistics, Hon. W. P. Reeves; Engineering, Prof. J. H. Biles; Anthropology, Dr. W. H. R. Rivers; Physiology, Prof. J. S. Macdonald; Botany, Prof. F. E. Weiss (Agricultural sub-section, W. Bateson, F.R.S., Chairman); Education, Rt. Rev. J. E. C. Welldon.

ASTRONOMICAL RESEARCH.—During the course of his recent Presidential address to the Royal Astronomical Society, Sir David Gill, after presenting Dr. P. H. Cowell with the Society's Gold Medal, took occasion to say that of the three national establishments devoted to the promotion of astronomy and navigation, two, namely, the Royal Observatories at Greenwich and the Cape, were equipped for research in two of the three great sub-divisions of Astronomy—Astrometry and Astrophysics. For the department of Astrodynamics there had been no national provision, and Dr. Cowell had accepted the Superintendentship of the Nautical Almanac Office with the hope of making that the centre of research in Astrodynamics.

A RARE COPPER MINERAL.

By Prof. PAUL DANIEL HAHN, M.A., Ph.D.

None of the heavy metals form a larger number of combination, which are met with in Nature than the well-defined minerals Copper and Lead. Even an ordinary student's Handbook of Mineralogy enumerates about 50 different minerals of which Copper is an integral constituent. This is mainly due to the property of Copper of readily forming under favourable conditions an oxide of a strongly basic character, which freely combines with acidic radicals formed in the disintegration and chiefly in the oxidation of the ores of Copper and of other metals. Of the numerous Copper minerals only a comparatively small number occur in large quantities in ore deposits, and the student of Metallurgy has rarely to pay attention to more than 12 or 15 of these Copper minerals. The Mineralogist and the student of Mineral-Chemistry, however, include all the numerous combinations in their studies, and the rare mineral naturally attracts their special attention.

The common Copper minerals, such as the Carbonates and Sulphides, have been observed in South Africa from the Knysna in the South to Broken Hill in the North, and from Damaraland in the West to Zululand in the East.

Already in the time of Governor Van der Stel an expedition was sent to Little Namaqualand to explore the Copper ores of that region, but only in the middle of the last century Copper ores were mined in the Western part of South Africa near the Coast. In recent times the Germans have started Copper mining in Damaraland and export at present more Copper via Swakopmund than we do from Little Namaqualand via Port Nolloth.

The Copper mines in Southern and Northern Rhodesia are now being developed, and we may expect that before long these mines in Central South Africa will also be productive of the red metal. The demand for Copper is constantly rising in connection with the development of all electro-technical industries, and it is not unreasonable to expect that Copper smelting and Copper refining will soon be established in those parts of South Africa, in which coal and water power is available at no great distance from the Copper ore deposits.

At Broken Hill and at the Tsumeb and Otavi Mines in Damaraland very beautiful Copper minerals, such as Malachite and Azurite, and exquisite pseudomorphous formations of Malachite and Azurite, have been discovered, the sight of which must gladden the heart of every true mineralogist. But the most interesting mineral which has been found in the Damaraland mines is Dioptase, one of the rarest, if not the rarest of all Copper minerals.

This beautiful mineral first became known towards the end of the 18th Century, when a few small specimens were brought to St. Petersburg from Mount Altyn-Tübe, in the Khirgas-Steppes. These specimens were first described as Emerald, but Vauquelin, the famous chemist, the discoverer of Chromium, proved that the

colouring matter of this new mineral was Copper, whereas the Emerald owed its colour to Chromium. In those days the mineral was very rare and Vauquelin had only 3½ grains of substance at his disposal. In his "Traité de Mineralogie,"* Haüy, the father of Crystallography, points out the distinguishing characters of Emerald and the new mineral to which he gave the name "Dioptase."

Haüy states his reasons for giving the name "Dioptase" in the following words :—

Lorsqu'on fait mouvoir une dioptase dodecaedre a la lumière, on aperçoit a l'interieur des reflets assez vifs. situés sur des plans sensiblement paralleles aux arêtes terminales ; de sorte que les joints naturels sont indiqués d'avance par ces reflets, en perçant, pour ainsi dire, à travers le cristal. C'est ce qu'exprime le nom de "dioptase."

This observation can be made with the fine crystals from the Tsumeb Mine.

At the Altyn-Tübe Mount the Dioptase is found in Limestone, and for a long time, till 1874, that locality was the only place where this interesting mineral was found. But already at the time of Haüy Dioptase was also observed associated with Malachite, as appears from the following passage :—

"J'ai appris de M. Inguersen, savant mineralogiste danois, que la dioptase se trouvoit en Siberie, sur une gangue recouverte de malachite." †

This is exactly the same condition under which the Dioptase is found in the Tsumeb Mine with Dioptase crystals embedded in fibrous Malachite.

In 1878 small crystals of Dioptase were found at Rezbanya, in Hungary, in clay with Wulfenite and Smithsonite; then in 1880 in Chili at Copiapo in cupriferous quartz, and in 1874 in the Congo Free State on the mine Mindauli, between Philippeville and Brazzaville.

The general characteristic features of this rare mineral, as discribed in the works of Miers, Naumann-Zirkel and Hintze, can be well observed in the specimens from the Tsumeb Mine.

The two chemical analyses which I made of the Tsumeb Dioptase gave the following results :—

	1.	2.
Cupric Oxide	50.08	50.10
Silica	37.15	37.13
Water	11.38	11.36
Oxide of Iron	1.38	1.39

These results agree with the formula : $SiO + CuO + OH_2$

It is very remarkable that the water is only expelled at a temperature between 400°C and 500°C. It is thus evident that the water contained in this mineral is not water of crystallization but water of constitution, and that, chemically speaking, Dioptase is not a hydrated cupric metasilicate, but an acid cupric orthosilicate.

I am greatly indebted to Dr. Haymann, General Manager of the Damaraland Copper Mines, who kindly placed the specimens of this beautiful mineral at my disposal.

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* Tome III. p. 139.

† Traité de Mineralogie, Tome III, p. 138,

LEAF-PROTECTION IN *OLDENBURGIA ARBUSCULA* DC.

By Rev. Frederick Charles Kolbe, B.A., D.D.

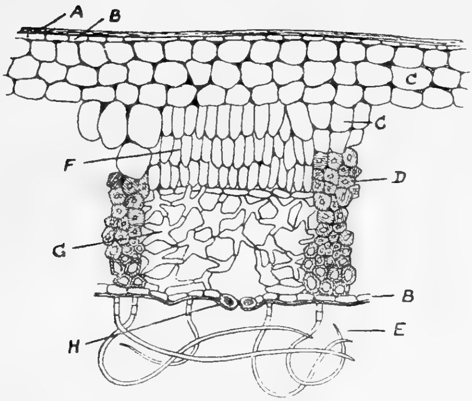
Among the devices adopted by plants for self-protection, those found in *Oldenburgia arbuscula* DC., deserve special study.

In this paper I limit myself to the lamina of the leaf. The stem and petiole are provided with an extraordinary hypodermal or cortical woolliness, the study of which would call for an investigation into development which I do not feel competent to undertake. Nor do I know what has been published about the anatomy of this plant. My purpose is merely to suggest to teachers the use of a native type of leaf-protection, which has not found its way into the text-books, probably on account of its inaccessibility in Europe or America.

The plant grows on dry hill-sides near Grahamstown, frequently in crevices or on ledges of rocks, and attains the dimensions of a tree-shrub, as its name indicates.

For purposes of comparison in the line of self-protection, we can put aside Xerophytic and Halophytic structures, and consider only those that arise from Sclerophyllous conditions. The principal types are familiar enough to us—the minute, half-rolled leaf of the Ericaceae (common to many of our orders)—the leaf that can roll itself up at need (as in several grasses)—the completely cylindrical leaf of Bobartia or Hakea—the leaf that turns its edges up to the sun (like many Proteas)—the leaf that buries its stomata in woolly pits (Nerium Oleander)—the leaf that hides its green and clothes itself in silk (like the Silver-tree)—and so forth.

With all their success, every one of these plants makes some confession of weakness. Either they hide their green, or refuse to face the sun, or diminish their size, or breathe with timidity through minute stomata with small air-spaces behind them. The *Oldenburgia* displays none of these weaknesses. Its brilliant green leaf faces the full glare of the sun, and is larger than most leaves of the sheltered forest. Its stomata are numerous, and of more than average size, and are, moreover, not only not hidden in recesses, but actually protrude above the surface. And by protruding I do not mean that there is an arched chimney of cuticle, as in the Proteaceae; the guard-cells themselves rise above the rest of the epidermis. Lastly, chief audacity of all, its spongy tissue, so far from being closely packed, is made up of stellate cells, which stretch out long arms to one another as they do in many water-plants. It looks as if the *Oldenburgia* has over-protected itself, and scornfully treats its dry hill-side as if it were the marshy top of Table Mountain.



EXPLANATION. *

A. Cuticle.	E. Whip hairs.
BB. Epiderm.	F. Palisade cells.
CC. Hypoderm.	G. Stellate cells.
D. Sclerenchymatic tissue.	H. Stoma.

In all the three devices common to the Heath, the Oleander and the Oldenburgia —namely, the cuticle of wax, the large water-containing epidermis, and the woolly shelter for the stomata—the *Oldenburgia* is easily first. The wax makes the dry leaf as stiff as a board. While the Oleander has 3 rows of epidermal cells, the *Oldenburgia* has everywhere 4, and in some places as many as 5 or 6. Thus the structure of the leaf is a net-work of sclerenchymatic walls dividing the whole into polygonal compartments : each compartment is occupied by a dome of green tissue whose head rises above the level of the walls : the whole is then covered by water-cells (4 above the domes, and 6 above the walls); finally, the upper side is roofed with its strong cuticle of wax, and the lower side is abundantly provided with matted hairs of the type which the Germans call whip-hairs—a pedestal with one cell for the stick, and a long cell for the lash. I suppose that during the rainy season the woolly covering absorbs so much water that the plant has to have an internal atmosphere to be able to breathe at all, while in dry weather the felt-like covering is effective enough to prevent excessive transpiration.

If I may be pardoned so rudimentary a remark, I should like to tell beginners that the leaf is quite easy to cut even in the dry state, provided of course one cuts from the lower side towards the upper; even if the section is not very thin, both stellate tissue and stomata are readily demonstrated.

* This figure is reproduced from a drawing made at the microscope by Miss Margaret Michell of the South African College.

NEW DOUBLE STARS.—In the Notes on Some Points Connected with the Progress of Astronomy during the year, appended to the 91st Annual Report of the Council of the Royal Astronomical Society, it is stated that Mr. Innes, at Johannesburg, has made careful estimates with the nine-inch Grubb refractor of the angles and distances of 268 new double stars, of which 115 have a separation of less than one second. This brings Mr. Innes's total discoveries up to 700.

ATMOSPHERIC VARIATION AS A FACTOR IN ORGANIC EVOLUTION.

By David Traill, M.A., M.B., Ch.M., B.S.

Before entering on the subject proper of my Paper, I will enunciate two propositions.

The first is: *The animal kingdom is dependent on the vegetable; and conversely, the vegetable is dependent on the animal.*

The truth of the first part of this proposition will at once be acknowledged, but the second part, namely that plant life is ultimately dependent on animal life, is not as self-evident. Indeed at first one is apt to say "What a riotous time of it plants would have if there were no animals to destroy and devour them." But the good time would be only of short duration. Animals are continually increasing the carbon dioxide in the air, plants remove some of this carbon from the air; part of the carbon is buried and permanently removed from the air. In this way plants, if alone on the earth, would gradually diminish the quantity of carbon in the air, and ultimately exhaust it, when all plant life would come to an end.

Thus we see that the vegetable kingdom is ultimately dependent on the animal.

The other proposition is: (1) *The more oxygen and the less carbon dioxide in the air the livelier and brisker the life of the animal living in that air;* (2) *the greater the appetite, but* (3) *the shorter the life; and conversely the less oxygen (within certain and safe limits) and the more carbon dioxide in the air, then* (1) *the more sluggish the life,* (2) *the smaller the appetite; but* (3) *the longer the life.*

This proposition is self-evident when we consider (1) the effect of pure oxygen on the burning of a fire and (2) the close analogy between the life of an animal and the life of a fire.

I shall now take up the subject of "Atmospheric Variation," and may here state that it is almost solely with the oxygen and carbon dioxide in the air that I shall deal, especially with their relative proportions to one another, and more especially with the variation of the quantity of carbon in the atmosphere.

I have chosen three special points in time, and I shall specially consider the relative proportions of oxygen and carbon dioxide to one another at these times. The three points of time are (1) at the beginning, (2) at the present time, (3) at the end.

(1) *At the beginning.* The "beginning" for us means the time of the first birth of organic life on our planet. What was the relative proportion of oxygen to carbon dioxide at that time? At the beginning, after this world of ours had solidified, and its crust had cooled sufficiently for organic life to start, the probability is that there was very little free oxygen in the air, most probably all of the present free oxygen being tied up with carbon in the form of carbon dioxide. Lord Kelvin was of this opinion. All the elements had been at a great heat, and had gradually cooled. The

presumption is that during the process of cooling, most of the available oxygen would unite with, and oxidise other elements, and that most of the carbon would unite with as much oxygen as it could get and so form carbon dioxide.

We thus see that, on theoretical grounds, there is good reason for believing that, at the beginning, there was abundance of carbon dioxide in the air, but little or no free oxygen. But we have something more definite to go upon. Let us, for a minute, leave the consideration of the carbon in the air at that time, and turn our attention to the large accumulations of carbon at the present time in the bowels of the earth, mainly in the form of coal. Where has all this carbon come from? It has gradually been withdrawn, in the past ages, from the carbon in the air by the action of plants.

Let us assume that at the beginning all the oxygen now present in the air was then present but attached to carbon in the form of carbon dioxide, and that the other constituents of the air were the same and in the same proportions as at present. On that assumption, one-fifth of the atmosphere would be composed of carbon dioxide. Now the weight of the air is equal to about 30 feet of water. Therefore the weight of the carbon dioxide would have been equal to about one-fifth of 30, that is about 6 feet of water. Now take carbon dioxide as equal to one atom of carbon and two of oxygen; therefore the weight of the carbon in carbon dioxide is equal to $\frac{12}{44}$ of the whole weight of the carbon dioxide, that is $\frac{12}{44}$ of 6 feet of water, *i.e.* $\frac{72}{44}$ or $1\frac{7}{11}$ feet of water.

That is, if all the assumed quantity of carbon dioxide in the air at the beginning were withdrawn from it, and converted into carbon, it would form a uniform seam of coal all over the world of about $1\frac{3}{4}$ feet in thickness.

Now let us try to estimate, it can only be roughly, the weight of the world's coal. First let us take that of Great Britain and Ireland. The following are figures taken from the Report of a Royal Commission on Coal, and founded on investigations made in the years 1866-1871. The quantities represent the aggregate yield of all seams over 1 ft. in thickness:—

Coal in exposed coal-fields within 4,000 feet=90,206,240,387 tons. The quantity estimated as lying below the 4,000 ft. limit not yet exposed in the central and northern counties of England was 56,248,000,000 tons, and of the non-available coal there is estimated between 4,000 and 6,000 ft. 26,341,659,067 tons, and between 6,000 and 10,000 ft. 15,302,741,333 tons; giving a total non-available of 41,644,390,400 tons, as compared with the total available of 146,454,240,387 tons.

What we are trying to estimate is the *total* quantity of coal in the bowels of the earth; whether available or non-available is all the same. We therefore get a grand total of 188,098 million tons estimated as existing in Great Britain and Ireland in 1877; and at that time the output had been going on for some time at the rate of 125 million tons per year. We thus see that before coal mining started in those islands, there must have been little under 200,000 million tons. Now if this quantity of coal were

evenly distributed over the entire area of Great Britain and Ireland what would be the thickness of the resulting seam? The area of Great Britain and Ireland is 120,832 square miles = $120{,}832 \times 5{,}280 \times 5{,}280$ square feet. Now one entire cubic ft. of coal weighs about 80 lbs. Therefore the weight of a uniform seam of coal one foot in thickness, spread throughout Great Britain and Ireland, would weigh $120{,}832 \times 5{,}280 \times 5{,}280 \times 80$lb.

But the estimated existing coal on the same area is nearly $200{,}000{,}000{,}000 \times 20 \times 4 \times 28$ lb. If we divide this long number of pounds by the former number of pounds, we get as a result $1\frac{3}{4}$ approximately. That is, if the total coal estimated as existing in Great Britain and Ireland were evenly distributed it would form a seam of about $1\frac{3}{4}$ ft. in thickness. This result is a wonderfully near approach to the result of our previous calculations. The result of these two calculations is this:—that supposing we take Great Britain and Ireland and shut them and their atmosphere off from the rest of the world and returned its buried carbon or coal back to the air in the form of carbon dioxide, the amount of carbon dioxide so returned would be just about 500 times the quantity of carbon dioxide in the atmosphere at the present time.

It may, however, be urged that Great Britain and Ireland have more than their share of the coal of the world; but on the contrary, it may be urged that many coal-fields have yet to be discovered. Japan has seams of coal 14 to 20 or more feet in thickness being worked, while in Manchuria, coal 100ft. thick is reported. But what of the coal under the seas and lakes? It was under water that the process of coal formation took place. To return, again, to the estimate of the total amount of coal in Great Britain and Ireland. The amount already given was only that of all coal over 1ft. in thickness. There must be large quantities of coal in seams under 1ft. thick. But besides coals we have other substances in the crust of the earth formed from plants, that is, from the carbon of the original atmosphere. We have peat, lignite, bituminous shale, etc. Then we have more or less carbon scattered throughout the other rocks of the earth's crust. Besides, we must not forget the carbon in the various Carbonates in the various strata of the earth.

I think, then, that we have good reason for believing that at the beginning there must have been a very considerable quantity of carbon dioxide in the air, of which most of the carbon is now buried in the earth, and of which the oxygen is now partly free in the air and partly buried combined as oxides.

Suppose every atom of carbon in the air at the present time were converted into coal, how much would it make? As there is now only $\frac{1}{500}$ of the amount of carbon dioxide assumed in my first calculation, the result must be $\frac{1}{500}$ part of the first result, that is, of $1\frac{3}{4}$ feet = about $\frac{1}{24}$ of an inch. Therefore the seam of coal formed by all the carbon in the air at the present time would be about $\frac{1}{24}$ of an inch in thickness. We thus see that, at the beginning there must have been a large quantity of carbon dioxide and very little oxygen in the air.

(2) *Next let us look at the present time.* The proportions of oxygen and carbon dioxide in the air at the present time are

known. About 20 per cent. of the air is oxygen and only about .04 per cent. carbon dioxide: that is there is about 500 times more oxygen than carbon dioxide. How has this come about? How has the carbon dioxide been so tremendously reduced in quantity? It has all been done by the action of plants, through the ages, on the carbon dioxide in the air. In the green parts of plants, that is in the presence of chlorophyll and in the presence of sunlight, the carbon dioxide of the air was split up into carbon and oxygen: the carbon was absorbed by the plant, and helped to form its leaves, twigs and branches. Some of these leaves, twigs and branches ultimately fell or were blown into water, where they became water logged and sank to the bottom. There they were preserved from contact with the air and its decaying influence, and ultimately helped to form a coal-bed. There is only one point to discuss with reference to the oxygen and carbon dioxide in the air at the present time. Is the carbon dioxide in the air still decreasing now as it has done for untold ages in the past?

Of late years a new process has been started by man: a process which acts in a contrary direction to that which Nature has been pursuing from the beginning. Man has unearthed the carbon buried by Nature, and has given it back to the air as carbon dioxide. Never was there a time when man was so extravagant in the use of Nature's stores. This is truly an animal age, with its almost innumerable animals, giving out carbon dioxide into the air. This is, therefore, an age, too, of the manufacture of carbon dioxide, just as the Carboniferous period must have been a vegetable age and an age of the manufacture of oxygen. Our question then is this:—Is man's extravagance such as to check for a time the gradual diminution by Nature of the air's supply of carbon? To assist us in answering this question let us again take Great Britain and Ireland, and again let us assume that the air above them was shut off from the rest of the air; and let us suppose that all the carbon in the enclosed space was converted into coal, the resulting amount would be about equal to two years' output at the present time. In other words, assuming that for these two years the plant and animal action on the carbon of the air balanced one another, and assuming that the two years output of coal were all burned in the enclosed area, the quantity of carbon dioxide in the air would be doubled at the end of the two years. Considering this fact, I am decidedly of opinion that at the present time the quantity of carbon in the air is on the increase, and will continue to increase for some hundreds or it may be thousands of years. This is a point which will be or at least ought to be definitely determined in a few years by means of careful experiments made, say, yearly, simply for the express purpose of determining this point.

But possibly the variation may be too small to determine chemically. Now sometimes, when chemistry fails to give evidence of a point, Physiology steps in. Let us see what Physiology has to say on this point. We remember the proposition that the less oxygen and the more carbon dioxide in the air, in which

an animal lives, the more sluggish is the life of the animal, but the longer. Gradual increase of carbon dioxide in the air then means (1) a longer life, (2) diminished need for food and (3) a more sluggish life. Now have we any signs of these three results being brought about? I think we have. (1) We have the average of human life getting longer. But some may say that this is due to advances in sanitation and medical science rather than to the increase of carbon dioxide in the air. (2) Are there any signs of animals needing less food nowadays? We have the growing conviction that we all eat too much, and a growing plea for a return to the simple life. May this need for less food not be in part an explanation of the growth of Vegetarianism. (3) Are there any signs of life becoming more sluggish? May we not take as a sign of this, the shorter hours' movement of the present day, a movement which seems to grow *pari passu* with the coal output, that is with the increase of carbon dioxide?

(3) *At the end.* We all know that the huge output of coal is merely a short episode in the world's future history. The available coal will in a few thousand years, at most, be at an end. Now as soon as the coal output is reduced to a certain point then there will begin again that process that has been going on from the beginning till recently, namely: the gradual diminution of the air's carbon. This process cannot go on for ever; a point will ultimately be reached when the carbon in the air has been so reduced that plant life will no longer be able to subsist.

We thus see that *at the end* of organic life there will be much oxygen and little or no carbon dioxide; while *at the beginning* there was much carbon dioxide and little or no oxygen.

Now for the question "When will the end of all living things come?"

Sir Robert Ball, in his "In the High Heavens," tries to show that the conditions on this earth cannot always remain such as are consistent with life. He says a time must come when, due to loss of heat of the sun by radiation, life will be no longer possible on our globe. He gives organic life here from four to ten millions more years. This estimate was made before the days of radio-activity. Nowadays it is recognised that, due to this newly recognised source of heat, the Sun's heat may continue as at present for countless millions of years in the future.

Now from considerations such as I have been making with regard to the steady withdrawal of carbon from the air, can any approximate estimate be made of the time that must elapse before the end of all living things? Any such estimate must be of the vaguest. Still a vague estimate may be attempted. There is the reason, I hold, for believing that at the beginning the quantity of carbon in the air was at least 500 times (it may be 1,000 times) the amount now present. There is also good reason for believing that for long years all through the oldest geological period, very little carbon would be abstracted from the air; and that this earth's atmosphere began the Carboniferous

period with its original supply of carbon little reduced. Let us assume, then, that at the beginning of the Carboniferous period there was still say 500 times the carbon now present, then we should estimate that the end will come in about $\frac{1}{500}$ of the years since the Carboniferous period began. Geologists put this period down as 30 million years ago. This gives us 60 thousand years as a probable estimate of the time before organic life must come to an end from carbon hunger. We have now traced the atmospheric variation, and more especially the carbon variation, from the dawn of organic life on this globe to its close; and we find that the birth of all things occurred in an atmosphere with much carbon, and that the death of all things will come when there is practically no carbon. Surely, then, carbon has been well called "the food of life."

Seeing what a stupendous change has been taking place in the atmosphere, and especially the change with regard to carbon, the food of life, we should expect to find a correspondingly great change in the nature of the organisms which have had to live in this changing medium, and which have had to adapt themselves gradually to it.

A few self-evident deductions may be made as to the effect of this changing atmosphere on organic life.

(1) Plant life must have been the first form of life, because of the large quantity of carbon dioxide and lack of oxygen in the air.

(2) Plants by their action on the carbon dioxide and the formation of oxygen prepared the way for animal life.

(3) At a certain stage the atmospheric conditions would become an ideally perfect one for plant growth, with carbon, the special plant food, hundreds of times more abundant than it is now, and with sufficient oxygen. This time of plant luxuriance began with the beginning of the Carboniferous period, and lasted for a considerable time after.

(4) As a result of the luxuriance of plant life, we would expect later a rapid development and increase in size of animals, first of the herbivorous and later of the carnivorous.

(5) Later, after this age of luxuriance of plant and animal life, we would expect a change in both, especially in the animal. Carbon has been rapidly removed from the air, and oxygen added, that is with diminishing luxuriance in the growth of plants, the animals' appetite is increasing owing to the increase of oxygen. Thus we get a growing appetite and a diminishing food supply. We would expect the largest animals to decrease in size, if they did not die out altogether.

Due to the diminishing carbon dioxide or plant food supply, and increase of appetite of the animals due to increase of oxygen, there would be (a) a general slow decline in plant luxuriance; (b) gradual reduction in the size of animals; (c) increased animal activity; (d) increased appetite of animals; and (e) shortening of the average animal life. We see here a reason why the ancient patriarchs lived much longer than we do now.

(6) It could only have been in very recent years that man and many other animals, as at present constituted, could have lived.

(7) In the future, we would expect plant life gradually to dwindle as carbon gets scarcer and scarcer.

(8) We would expect the highest power of cerebration with the most complete oxidation of the blood. In the future, then the atmospheric condition will be even more favourable to mental activity than at present; owing to the increase of oxygen in the air.

There are still certain deductions of more general application than those already given.

(9) Plant life under water, being less directly under the influence of the air changes, would change less than the aërial plants.

(10) The lungs (or breathing organs) of animals, would, as the oxygen became more plentiful, be expected to diminish in proportion to the rest of the body.

(11) Similarly we would expect the lungs of plants (namely, their leaves) to increase in size relatively to the size of the plant, as the carbon dioxide in the air got less and less.

(12) The temperature of animals should rise as the oxygen in the air increases, due to improved oxidation. We thus see the reason of the change from cold-blooded to the warm-blooded animals of the present day.

In conclusion I will indicate some directions in which experiments might be made.

Plants: We often hear of the experiment of growing plants under electric light, and of passing electric currents through the soil in which they are growing. Experiments, too, on the effects of various manures, that is foodstuffs, given to the roots of plants are being continually tried. But I have not heard of what one would think would be the most natural way of stimulating plant growth, and that is by increasing its aërial food, the carbon dioxide in the air.

In experimenting on the effects of increased quantities of carbon dioxide in the air the quantity of carbon dioxide would have to be gradually increased, and that of oxygen correspondingly decreased; and the more gradual the change, the greater would be the ultimate effect on the plants. One would expect primitive plants to respond most readily to this experiment. After a certain point was reached in the relative proportions of carbon dioxide and oxygen we would expect the most highly developed, that is the most recently evolved plants to die.

Animals: Experiments made on similar lines with animals we would expect to produce similar results. As the carbon dioxide increased, and oxygen became less, soon the more highly developed animals would die. Suppose this experiment to be carried on indefinitely and with infinitely small changes in the proportions of carbon dioxide to oxygen, we would expect ultimately to get back to the most primitive form of animal life.

We are speaking of Atmospheric variation as a factor in *organic* evolution, but nowadays there is also an *inorganic* evolution talked of. By inorganic evolution is meant, in the words of Professor Duncan, that

"The 80 odd elements of matter as we know them on the earth to-day were not specially created, but like the plants and animals they have truly evolved from simpler and still simpler types back to some really simple elements from which they have all evolved through infinite aeons gone by.' *

The simplest forms of matter appear in the hottest stars, where the elements of lightest atomic weight first appear; then as the temperature gets less, more complex elements appear, until ultimately, at the ordinary temperature of to-day we have the varied and complex matter of to-day. We see then that the governing factor in inorganic evolution is change of temperature. Now let us turn to *organic* evolution. Here the change is from the lowest form of plant life to the highest form of animal, as exemplified in man or *homo sapiens*. In bringing this great change about, I hold that the most potent factor was the accompanying change which was going on gradually and steadily in the atmosphere, namely the gradual elimination of carbon from it. Just as a change of temperature was the dominant factor in inorgaic evolution so was change of air, that is, change of food, the dominant factor in organic evolution. This, too, is just what we should expect. For as temperature is the most important condition to an *inorganic* substance, so is *food* the most important to an *organic*. The quickest way of producing a change in an inorganic substance is to change its temperature, so, with a living organism, if you want to change it, change its food. I am told that it is now possible to rear as many queen bees as you wish in one hive, simply by feeding as many ordinary bees as are required on the special food usually reserved for the queen bee; and by giving them, of course, the necessary room for expansion. It is also by change of food under cultivation and domestication that we have got such a rapid improvement of late years in so many of our flowers and domestic animals.

Now, since the dawn of organic life, the food of all things living has ben gradually changing; for the air in which they live and move, and from which they have their being has been changing; the carbon dioxide for the plants has been getting less and less, while the oxygen for the animals has been getting more and more. It may be urged that, at the beginning the conditions were favourable to plant life, but unfavourable to animal life; and that thus there is a difficulty in explaining the origin of animal life. There is an appearance of truth here, but that is due to our thinking of animals as we know them to-day, and forgetting that the first animals would be such as could live in a minimum of oxygen.

Let me here recall the proposition with which I started, namely, that not only is the animal life dependent on the plant life, but conversely plant life is ultimately dependent on the

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* R. K. Duncan: "The New Knowledge" p. 206.

animal. In fact if animal life had not been evolved on this planet but plant life only, then long ago, in fact many millions of years ago, this world of ours would have been a howling wilderness with an atmosphere void of carbon.

We thus see that organic evolution has proceeded among the two lines of plant and animal; and from the fact that they are each dependent on and helpful to the other, it might be argued that here we have evidences of design and pre-arrangement. Now design and pre-arrangement in a case like this, presuppose omnipotence and omniscience. I do not suggest that the pre-arrangement meant certain special acts of creation or special interferences with the workings of Nature's laws then in force. The logical position to take is, that there has been pre-arrangement all through. This means that we accept the theory that nothing happens by chance; but that everything happens according to general laws fixed at the beginning, laws that are as uniform and unalterable in their action as the law of gravitation.

Our problem is to find evidence of some such general law in accordance with which the evolution of organic matter has been brought about.

I have already stated my opinion that the change in the atmosphere has been the dominant factor in bringing about this evolution; but what is the law in accordance with which this change of atmosphere, that is, this change of food, has brought about this change of organism?

Let us turn to Darwinism for a little. We find that Darwin in his "Origin of Species" takes no account of atmospheric change. He never mentions it. He practically ignores, too, tne effect of the change of food on living organisms. He says: "How much a direct effect difference of climate, food, etc., produces upon any being is extremely doubtful."

Seeing then that Darwin completely ignores this atmospheric change, and seeing that I hold it to be so important, I have had to look elsewhere than to Darwinism for the general law under which organic evolution has been brought about. But, meantime, I will consider Darwinism for a little, and later on I will attempt to propound a new theory of my own. Darwin states his position thus:—

"As many more individuals of each species are born than can possibly survive, and as, consequently, there is frequently recurring struggle for existence, it follows that any being if it vary, however slightly, in any manner profitable to itself, will have a better chance of surviving and thus be naturally selected. From the strong principle of inheritance, any selected variety will tend to propagate its new and modified form."

My objections to Darwin are as follows:—

(1) Darwin assumes that the selected variety will propagate its new form. Now there are two kinds of modifications an organism can acquire. (a) Modifications acquired in the lifetime; (b) innate ones born with the organism; called also respectively exogenous and endogenous. Now it used to be accepted that the first sort, *i.e.*, the modfications acquired in a lifetime, were inherited. Indeed, Herbert Spencer once said:

"Either there has been inheritance of acquired character or there has been no evolution."

And yet Professor Thomson states:

> "We do not know of any clear case which would at present warrant the assertion that an acquired modification is ever transmitted from parent to offspring."

So we see that nowadays it is not believed that exogenous modifications are inherited. My first objection then to Darwin is that he assumes the transmission of exogenous modifications. It is merely an assumption. He makes no attempt to prove it.

(2) He cannot explain the surviving of those varieties or modifications which he says survive. In one passage, in discussing the development of the eye, he says:

> "We must suppose that there is a power always intently watching each slight *accidental* alteration in the transparent layers and carefully selecting each alteration which may in any way tend to produce a distincter image."

Here he pictures the *Deus ex machina* as watching to see what variations may *accidentally* crop up, just as a gardener watches his bed of young seedling flowers. In another passage he says:

> "I have sometimes spoken as if the variations had been due to chance. This of course, is a wholly incorrect expression; but it serves to acknowledge plainly our ignorance of the cause of each particular variation."

In another passage he again confesses to this same ignorance. He says:

> "We are profoundly ignorant of the causes producing slight variations."

My second objection is then that Darwinism can give no explanation of the survival of the fittest.

I will now consider my new theory, and return later to further objections to Darwin's, when I will be able to compare the working of the two.

By way of introduction to my theory, let me consider the power which animals admittedly have of regulating the heat of their bodies. This is explained by saying that these animals have a heat regulating centre in the brain. Due to this heat regulating centre, the temperature of our bodies is about the same, in the hottest day of summer and the coldest night of winter. Plants, too, have this heat regulating mechanism. They keep their temperature down in hot weather by increasing the evaporation. The splitting up of carbon dioxide into carbon and oxygen, besides being a nutritive process, is also a heat regulating one. In this process of splitting up carbon dioxide into carbon and oxygen heat becomes latent, and has to be got from the plant and its surroundings.

I go even further and state, that not only in every living organism is there a heat regulating process going on, but we have it too in the inorganic world. Let us consider the act of burning, as in an ordinary coal fire. There is a popular idea that a fire burns best on a cold, frosty night, and that the sun shining on a fire tends to put it out. I remember when I was a student of Edinburgh University, in the Natural Philosophy classroom someone handed up a question on this point to Prof. Tait. He pooh-poohed the idea of the sun tending to put out the fire. He said the heat and light of the sun caused us to

neglect the fire, which went out in the usual way, owing to want of fresh fuel. But this is not, in my opinion, the full explanation. We know that sunlight is essential to the splitting up of carbon dioxide into carbon and oxygen. Surely then such sunlight must have a retarding influence on the re-union of the same carbon and oxygen.

Here then we have reason for believing in a heat regulating centre in the fire, or rather in every atom of carbon and oxygen, regulating their degree of chemical affinity for each other. We see, then, that this heat regulating mechanism is not confined to living organisms, but extends to so-called dead, inorganic matter.

I have said that as change of temperature was the dominant factor in inorganic, so change of food was the dominant factor in organic evolution. I have also said that as heat was the most important condition to the inorganic, so was food the most important to the organic. We have some reason to believe that inorganic matter has a heat regulating centre; so, by analogy we would expect the organic to have something higher, and more appropriate to its increased needs; that is a food or nourishment regulating centre, very analogous to the old heat-regulating centre and exercising its control in a similar way. The old recognised heat-regulating centre in animals, controls the heat of the body mainly by (1) regulating the amount of evaporation, that is the cooling process, or (2) by increasing the oxidation of the carbon of the food by the oxygen in the air respired, that is the warming process. We see, then, that, in animals, as we have already seen in plants, the heat regulating processes are really parts of the nutritive processes; the only difference between the plants and the animals being that the main nutritive process in the plant, the splitting up of carbon dioxide is a cooling process, whereas, as was to be expected, the reverse process, the re-uniting of carbon and oxygen in animals is a warming process just as it was in the fire; the more sun and the more heat, the less readily do the two re-unite to form carbon dioxide.

We see, then, that the new food regulating centre is practically after all our old established friend the heat-regulating centre, but with a new name.

The general law, then, for which we have been in search, the law in accordance with which organic evolution has been brought about, is as follows:— (This, too, expresses my new theory of evolution.)

In every organism there is a food regulating (or as I prefer to name it) *a nurture regulating centre, which is constantly receiving an ever varyng account of every condition, internal and external to the organism, and is as constantly adapting the organism to these varying conditions by regulating the nurture of the various parts in the way that is best for the organism as a whole.*

I simply take the old recognised heat regulating centre, and give it a new name.

According to my theory, this centre is a kind of central bureau which is constantly posted up in every circumstance affecting the

organism in the slightest. It is constantly getting new information and as constantly setting its machinery in motion so to modify the organism as to make the best of the new conditions. Again, this regulating centre may be compared to a perfect nurse in charge of the body. I hold, then, that in every organism there is this perfect nurse in charge, knowing everything affecting the body, and making the best of the means at her disposal, for the good of the organism as a whole.

Evolution, then, which I take to be the constant change due to the constant adaptation of the organism to the constantly changing conditions is thus never at rest in any organism. In the so-called fittest, and in the so-called unfit, this evolution is constantly going on under the control of the all-knowing and all-wise nurse in charge, the nurture regulating centre.

Now for a few examples of the working of this law :— ,

If an eye or a muscle is not being used by an organism the nurture regulating centre knows, and gradually reduces the supply of nourishment to the part, and has thus more to spare for the rest of the organism.

If by accident or by amputation an animal loses a limb, the centre knows of the altered condition at once, and begins at once to regulate the nurture supply to the new conditions : less is sent to the shortened limb, and the blood-vessels are gradually occluded.

Take, again, gangrene of the foot, or the homely boil. We all know what happens. There is some poison, in each case, detrimental to the organism as a whole. The centre knows this, and gradually cuts off all supplies to the noxious parts. Ultimately the foot is thrown off for the good of the whole. Take another example : sometimes it is necessary to tie a main artery, say the femoral. Here the centre gets news at once that the food supply to one leg has been almost completely cut off. The centre at once sets the machinery in motion, and starts to open up new channels, and to widen existing side-channels. These are gradually widened, and in a few days the leg is getting its usual amount of food (and heat, too) by newly established routes. Here we have a distinct variation evolved in the course of a few days.

Let us now take examples of the slower working of this law, and compare it with Darwinism. Let us take the black skin of the Negro. Let us start with white skins in a temperate climate, and let us assume that the white skins are suddenly transplanted to a much warmer climate.

According to Darwin, of the first generation born under the new conditions, a few would be slightly darker than the normal. Those darker ones suited the conditions best, and survived through a bad drought. Of their offspring, again, some were slightly darker than the others, and again proved fittest. In this way the Negro skin was, according to Darwin, evolved from the white. Now for my explanation : Here, too, let us start with the white skin put under the hot sun. As soon as they are transplanted to a hotter clime, the centre knows, and at once begins to make the best of the means at disposal, by regulating the

nurture of the various parts in the way that shall be best for the organism as a whole. In this way, certain cells under the skin are gradually so modified by a change of nutrition that dark pigment is deposited within the cells, thus acting as a shade to the rest of the body.

Take, again, the lizard-like creatures that used to live in the Karroo many million years ago. They are supposed to have arrived with short, feeble, crawling limbs; but finding here a series of swamps they gradually developed powerful walking legs. We know the explanation according to Darwin: the gradual evolution of the long strong legs by the weeding out of the weaklings, or rather of the short legs.

According to my theory, the all-wise nurture regulating centre in all the lizard-like animals knew at once of the new condition, and recognised the extra work that these new conditions put on the limbs. Therefore, for the good of the organism as a whole, an extra supply of nourishment was sent to the limbs, at the expense of the other parts. The limbs of all animals gradually respond to this liberal treatment, and gradually increase in length and strength. No need here for the slaughter of the weaklings.

Take another instance, suggested by this last one. Some animals, when they lose a limb or part of a limb, have the power of renewing the lost part. How does Darwinism explain this? According to my theory, as soon as a limb is lost, the centre knows, and knows, too, that it is for the good of the organism as a whole to have the lost member replaced. The centre therefore sees that the usual, or more likely an extra, supply of nourishment is sent to the damaged part till the lost limb is replaced.

Cases such as the last would seem to indicate that this centre in the lower organism has a greater power of controlling, regulating or altering the organism than in the higher forms. And this is as we would expect; the lower, that is, the younger, a form of life is, the more plastic it is.

Now to return to the objections to Darwinism: I have already mentioned two.

(3) Natural selection, according to Darwin, is, as Prof. Arthur Thomson puts it, Siva the Destroyer. It works by weeding out the weaklings, by a slaughter of the innocents. In my Negro example, if the "white skins" had found their new country "flowing with milk and honey" and therefore had no struggle for existence, no evolution, according to Darwin could have taken place.

(4) The fittest do not always survive. In war times, the bravest and best usually volunteer. The *stay-behinds* have the best chance of surviving. When the volunteers go into battle, again, the *stay-behinds* have the best chance of survival. So, too, with animals in the battle of life. In herds of gregarious animals, the boldest of those that wander furthest afield run the greatest risk of being caught by carnivora. We even see this in a brood of young chickens; the best foragers are the ones most likely to come to grief. The result of our observations may be summed up thus. The pioneers run the most risk, the *lag-behinds* and the *stay-at-homes* have the most chance of surviving.

(5) The weaklings prove often the most highly developed in certain directions. Look at the gardener watching this bed of young seedlings and flowers. Anyone who knows anything about flowers, knows that the strong rank-growing seedlings which if left to Nature would choke the weaker ones, are likely to be worthless. I once heard of someone consulting a Cape Town nurseryman for some hints about growing seedlings. The main hint he got was, "Nurse the wee ones." In his experience the *wee ones,* the weaklings, were the ones likely to show some new variations, such as a new shade of colour, or shape of flower. And this is just what one would expect from my theory. Just as in man, we do not expect exceptional physical and mental development, so in the plant we must not expect strong growth both of the nutritive parts, such as the leaves or branches, and of the reproductive parts, as the flowers. According to my theory, the nurture regulating centre has a certain amount of nourishment at its command, and it is the duty of this centre to distribute it in the way that shall be best for the plant as a whole. Hence if the plant is going to have specially double flowers it is only natural that a greater share of nourishment be held in reserve for this object, and thus less will be available for the grosser parts of the plant.

The same applies to animals. The small, weak Kerry cow would have no chance with the Africander, yet the Kerry with her milk supply large in proportion to the size of her body is on this account the more highly developed animal.

(6) According to Darwin's theory, only the few take part in evolution. According to mine, every living organism down to the lowest and the weakest is doing its little best to keep itself in unison with its surroundings. Darwinism is the rule of a despotic oligarchy; the rule, according to my theory, is that of democracy in its best form; where every indivdual member of the large community attends strictly to his own affairs, and makes his little lot as perfectly attuned to its surroundings as possible.

(7) The last objection is, to my mind, the strongest one. According to Darwin, evolution is not constantly acting. Now we are looking for some general law according to which evolution has been brought about. We would expect that this law, like all the other general laws of Nature, besides operating (1) *universally,* that is in every living thing, would operate (2) *constantly;* in fact, we would expect this general law to be *always* acting in *all* living things. Darwinism fails in both these points. We have seen that it acts only in the few. Now, we will show that it does not *always* act. It acts by fits and starts. To return once more to the Negro example: if the new land to which they were brought had been a land of plenty for all, then, while the time of plenty lasted, there would be no evolution. Then a famine comes along, and a new variation crops up and is fixed; later on comes a season of plenty, and again no progress. Thus, according to Darwin, evolution proceeds by short jerks. We are often told that

"The mills of God grind slowly, but they grind exceeding small."

But they also grind smoothly: there is no jolting of the machinery. In my opinion evolution according to Darwin proceeds by a long series of small jolts. It lacks the smoothness of Nature's other laws. The ancients recognised this smooth way of Nature's workings. They expressed it thus in Latin: "*Natura non facit saltum.*" Nature does not progress by leaps and bounds.

According to my theory, the dominant factor in evolution, the steady withdrawal of carbon from the atmosphere has mainly brought about the correspondingly steady change in the animal organism. Everything that has lived in the past has added its little to the steady stream of evolution. The Classical quotation which best sums up my views on evolution is not the Latin one already already given, though it fits it, too, but the Greek one, πάντα ῥεῖ is true in a double sense. Its usual meaning is that everything is in a state of flux or is changing. Of course, this is true of everything in Nature. But the special meaning I give it here is that everything is following on, everything is helping on the *steady* flow of evolution. In this sense πάντα ῥεῖ cannot be said of Darwinism.

Before closing the consideration of my objections to Darwinism, I will repeat one that I made at the start, namely: that Darwin admits that he can offer no explanation of the origin of those varieties which he says survives. Prof. Arthur Thomson admits that Darwin has no explanation to offer of the growth of the tree of evolution. He puts it thus: "Natural selection prunes a growing tree." Darwinism, then, explains the use of the pruning knife, but makes no attempt to explain the growth of the tree.

I think that I have shown how the general law which I have enunciated, the law which has worked in every living thing steadily through the ages of the past, has brought about the growth of the tree of evolution.

Just a word in conclusion as to the factors in their evolution. I have been constantly mentioning one, that is the steady withdrawal of carbon from the atmosphere. I have done so because so far as I know it is the only factor that has worked so steadily in the same direction through all the ages. Other factors have been at work, such as alterations of heat and cold, drought or famine alternating with plenty, but these changes were of the nature of slight oscillations and did not help on much the progress of evolution. From these alternating conditions we have a change of external conditions of a totally different nature in the tremendous change in the atmosphere. Here we have as complete a swing of the pendulum as it is possible to conceive: not a large number of little oscillations, but one long, steady swing of the pendulum from much carbon-dioxide and little or no oxygen to the other extreme of much oxygen and no carbon dioxide.

It is for this reason that I say that Atmospheric Variation has been the dominant factor in organic Evolution. To return for a moment to the rather pessimistic conclusion at which I arrived at the end of the first part of this paper, namely: that at a date not

so very far distant all life on this planet would come to an end from carbon hunger; after my remarks as to evidence of pre-arrangement in having life evolved along two lines mutually helpful to each other, and especially after my objections to Darwinism for his slaughter of the innocents, it is a sort of *reductio ad absurdum* on my part to predict such a wholesale slaughter at the end of all things. There is something in this objection. It might almost be urged that if my conclusions are correct, this *reductio ad absurdum* is an argument in favour of the transformation of matter. So to ward off this universal death from carbon hunger, there may be suggested some new source of carbon. It is rather peculiar that nitrogen is the element just above in the atmosphere. Any atom of nitrogen which broke up owing to the escape of some of its electrons might find its next state of stable equilibrium as carbon.

Again, there is the possible source of fresh carbon from the sun. Carbon electrons are being constantly repelled by light pressure from the sun, and are as constantly bombarding the earth. But I think that these suggested sources of new carbon are rather fanciful. We must get out of our difficulty in some other way.

We are often told that the evolution of the individual from the ovum to the end, is a short epitome of the evolution of the race from the beginning; and as every individual has to come to an end; so, by analogy, we would expect the race to come to an end, too; it may be to be followed, like the individual, by other and higher ones.

DARK NEBULAE.—In an article by Mr. R. T. A. Innes in the *Transvaal Observatory Circular,* No. 5, on the region around S Coronae Austrinae, the remarkable starless space in the neighbouring sky is discussed. In Vol. 9 of the *Cape Observatory Annals* Mr. Innes had recorded the fact that the 10th magnitude star Cor. D.M. -36° 13208, on the borders of the starless patch, was invisible during the years 1899—1901. On the other hand, Mr. W. M. Worssell, of the Transvaal Observatory, studying the region in question, found that the star is now visible, and ranging in magnitude from 11.0 to 12.2. The conclusion arrvied at is that the dark patch in the sky surrounding this region—and possibly also similar starless patches in other parts of the sky—is due to irregular sheafs of gas, that where those sheafs are thickest there is an absolute blackness in the sky, but that in the thinner portions stars are capable of shining through the intervening gas, but with a nebulosity somewhat like that of a street lamp in a fog. The temporary obscuration of the star above mentioned is assumed to be due to an extension of the obscuring medium across the line of sight, and its recovered visibility to a subsequent contraction of the interposed gas. Mr. Worssell found that there was a distinct difference in tint of the sky when the field of view crossed the edge of the dark patch.

A BRIEF OUTLINE OF THE FACTS CONCERNING THE COMPOSITION OF THE SNAKE FAUNA OF SOUTH AFRICA AND ITS RELATIONSHIP TO THE MADAGASCAR FAUNA.*

By JOHN HEWITT, B.A.

In the proceedings of the Transvaal Biological Society, February, 1910,† I tried to show that the lizards of South Africa resolve themselves into two sections, ancient and modern, the former including families which are either quite peculiar to the region, or which are well represented in the sub-continent, occurring sparsely or not at all in Northern or West Africa, and the latter composed for the most part of species which are merely the South African representatives of a fauna more strongly developed in the northern parts of Africa; the older section is closely allied to the lizard fauna of Madagascar, whilst the more recent fauna is not represented in that island.

Those facts certainly favour the hypothesis that the land masses of Southern Africa (Cape Province of Mr. W. L. Sclater) and Madagascar have been united during a late secondary or early tertiary period, perhaps even forming for a time a large continental island, and afterwards when Madagascar had separated off, the African continent assumed its present shape and South Africa became invaded by a new assembly of lizards which came from the North or West Africa; there is also evidence that this Ethiopian area was about the same time connected both with South America and with Southern India. In this paper it is intended to show how far the evidence of the snakes will conform to the same theories.

A cursory examination is sufficient to show that the parallel phenomena are not so obvious amongst the snakes, but nevertheless the broad facts of the case do not conflict with those relating to the lizard faunas.

At the present day the families of snakes have on the whole a much wider distribution than the families of lizards, so that there are none peculiar either to Madagascar or to South Africa, and in dealing with the present question it will be necessary to consider the general distribution of the Ophidian families over the earth's surface, which distribution is shown in tabular form as

* Revised by the author, March 16th, 1911.

† Ann. Tran. Mus. II. 56.

follows :—

	Africa	Madagascar.	Europe	Asia	Am'rica	Australia	Remarks.
Typhlopidæ	×	×	×	×	×	×	This distribution applies to the genus Typhlops.
Glauconidae	×			×	×		Very poorly represented in Asiatic region.
Boidae	×	×	×	×	×	×	
s.f. Pythoninae	×			×	×	×	The genus Python in Tropical and South Africa. Asia and Australia.
s.f. Boinae	×	×		×	×		In Africa confined to the northern half.
Ilysiidae				×	×		
Uropeltidae				×			Ceylon and Indian Peninsula.
Xenopeltidæ				×			One species only in India and Malay region.
Colubridae	×	×	×	×	×	×	
s.f. Acrochordinae				×	×		Aquatic snakes.
s.f. Colubrinae	×	×	×	×	×	×	Only few in Australia.
s.f. Rhachiodontinae	×						Only one genus *Dasypeltis* of two species.
s.f. Homalopsinae		×		×		×	Aquatic snakes. Only one species known in Madagascar.
s.f. Dipsadomorphinae	×	×	×	×	×	×	

	Africa	Madagascar	Europe	Asia	Am'rica	Australia	Remarks
s.f Elachistodontinae				×			Only one species.
s.f. Hydrophinae							Marine. Indian and Pacific Oceans.
s.f. Elapinae	×		*	×	×	×	Especially in Australia *lower miocene of Germany.
Amblycephalidae				×	×		
Viperidae	×		×	×	×		
s f. Crotalinae			*	×	×		*Miocene of Turkey.
s.f. Viperinae	×		×	×			

The Palaeophidae, a fossil family of large marine snakes, is known from the lower and middle Eocene of Europe and one genus Pterosphenus occurs in the middle Eocene of Egypt and of Alabama.

It will be seen from the above that the Asiatic region (including therewith the European) has representatives of every family and sub-family of snakes with but one exception (the Rhachiodontinae, comprising the single genus *Dasypeltis*); America ranks next in importance, having much in common with the Asiatic fauna, but lacking several families; Africa is well represented, but is without any members of about four important groups which are common to the Asiatic and American regions; Australia has a smaller number of families, and Madagascar is still more poorly represented. The groups common to all these regions are Typhlopidae, Boidae, Colubrinae, and Dipsadomorphinae, and it is important to note that the former two families are amongst the most primitive of snakes, still retaining the character of the hind limbs, whilst the Colubrinae is the least specialised group of the very large family of Colubridae, and Dipsadomorphinae comprises snakes which are not much modified from the primitive type. Now the Madagascar Ophidian fauna consists simply of the above-mentioned four cosmopolitan groups of comparatively primitive snakes, and in addition but one odd species, constituting a peculiar genus, of the aquatic Homalopsinae; this latter snake belongs to a family which

is characteristic of the East Indies, extending to Australia and Papuasia, but does not occur in Africa nor in America. So far as I know the question of the genetic relationship of this snake has not been investigated by morphologists, and, as it is not unlikely that some of the more specialised groups of Ophidia present cases of convergent evolution, it would be unwise to lay great stress on the fact of the existence of a solitary Homalopsine in Madagascar; in the absence of more complete data the most obvious explanation would represent this snake as a relic introduced at the time of a land connection with the Indian region.

The Ophidian fauna of South Africa is considerably richer than that of Madagascar, for, in addition to the four groups of more primitive snakes, our region has the following:—Glauconidae, Rhachiodontinae, Elapinae and Viperinae. Now, the two latter families comprise the very specialised poisonous snakes, which no doubt are comparatively recent developments from more generalised harmless snakes; the rhachiodont *Dasypeltis* is derived from a simpler Colubrine type, and the Glauconias alone are more or less primitive; that is to say (the Glauconias excepted) that portion of the South African Ophidian fauna which has no allies in Madagascar represents the last stage of evolution, and if it can be shown that the four generalised cosmopolitan families in South Africa have sufficiently intimate relationship with the same families in Madagascar, no one will doubt but that these generalised families constituted the fauna of the island continent which united Southern Africa and Madagascar, and that the other South African families come from the outside or less probably were developed *in situ* subsequent to the separation of Madagascar.

GLAUCONIDAE.

The distribution of the genus *Glauconia* is more restricted than might have been anticipated from consideration of its primitive nature. At the present day it occurs in Central and South America, in Martinique and Barbadoes and throughout the whole of Africa, an odd species extending as far as Sind (British Museum Catalogue).

This distribution agrees fairly well with that of the Amphisbaenidae, and these two groups offer the only certain instances (excluding the genus *Leptodira* and one or two almost ubiquitous genera of geckos and skinks) amongst South African snakes and lizards of a decided American relationship. West Africa, however, affords additional evidence, and it is commonly accepted by palaeontologists and zoologists that there must have been a land connection between Africa and South America during a late secondary and early tertiary period.*

At that period the connection with America was no doubt solely through West Africa.

*See Boulenger on distribution of Characinid and Cichlid fish in Report British Association, 1905, and Schönland in Trans. S.A. Phil. Soc., 18, p. 321, where the case is very clearly stated from the botanical side.

TYPHLOPIDAE.

The very large genus *Typhlops* has eight species in Madagascar and about 12 species in South Africa. Only one species is common to the two areas, but this, T. braminus is of wide distribution in Africa and Asia.

BOIDAE.

Madagascar has three species belonging to as many genera; one of these is assigned to the American genus Corallus, and the other two were placed by Boulenger in the American genus *Boa*, but have been restored by Mocquard to their former position as distinct and peculiar genera related to *Boa*. These three species belong to the sub-family Boinae. In South Africa the Boinae are not represented, and there is only one species of the Pythoninae, viz., *Python sebae*, which ranges from Senegal to the Cunene River and from White Nile, East Africa, to Natal. The genus *Python* is distributed in the following regions: Australia, Papuasia, South-East Asia, Tropical and South Africa. The Boinae have their headquarters in South America, and though absent from South Africa do occur in Equatorial and North Africa, being represented by several species of the genus *Eryx*, which has other species in South and Central Asia; this sub-family also extends to New Guinea, Fiji and other Pacific islands, which distribution area recalls that of the Iguanidae (South America, Madagascar, Fiji Islands).

To connect together these several facts is not a simple matter, for it is highly improbable that the same or closely related ancestors gave rise in Madagascar to three distinct Boine genera and in South Africa to a species of *Python*. Indeed, judging from the distribution of the genus *Python*, the South African species would seem to have entered the sub-continent from the north, probably during early tertiary times, and it is just possible that the only survivors in Africa of the Boinae group, which presumably inhabited the Ethiopian island, are the several species of Eryx found in East and North Africa, the Asiatic species of that genus representing a further emigration eastwards. But, in view of the supposed affinity of the Madagascar species with present-day American forms, it is more probable that these species of Eryx are not directly related to the Madagascar Boinae, though they may be independent arrivals from America.

It is very difficult indeed to satisfactorily account for this and similar cases (Iguanidae) of apparently pronounced relationship between the South American and Madagascar fauna with no connecting link in Africa, whilst in other cases such a link only occurs in West Africa (Dendrobatidae, Madagascar and French Congo).

So far as these Boinae are concerned, they are certainly an ancient group of snakes, and in a general way we may explain the apparent anomaly of distribution by regarding the present day forms as remnants of a once flourishing group perhaps almost cosmopolitan in its distribution.

Possibly palaeontology will eventually furnish the solution, as in the case of the tortoise Podocnemis which to-day is known only in South America and Madagascar, but occurs also in the eocene beds of Fayoum (Egypt) and in the lower eocene of England and of India;* and the gap in the distribution of the Iguanidae may perhaps be filled up by the Paliguana of Dr. Broom.† In this connection it may be mentioned that a very large snake, Gigantopis, related to Python, is described by Andrews from the Eocene of Fayoum, and there is a pythonid genus in the upper Eocene and lower Miocene of Europe, but the relationship of these to the present-day genera of Boidae is unknown.

But to return to the Boinae. According to Beddard, who has made extended and valuable investigations on the anatomy of reptiles, there is reason for doubting the commonly-accepted belief in the close affinity of South American and Madagascar Boidae; after comparing the internal structure of Corallus Madagascariensis with the American species of Corallus he suggests that they should be generically separated (P. Z. S. 1908, p. 135), and in fact it appears that the former snake is more in agreement with the pythons than with the boinae in respect to its arterial arrangement. And Mr. Beddard now thinks that in view of facts accumulated since the division of the Boidae into its two sub-families it is not so desirable for the present to insist upon any such sub-division. More recently (P. Z. S. 1909, p. 918), on comparing several American species of *Boa* with the Madagascar species (*Pelophilus Madagascariensis*), he finds important anatomical differences, whilst there are close points of agreement in the arterial arrangement of the Madagascar genera Corallus and Pelophilus. In view of these conflicting facts it is obvious that the evidence of the Boidae on questions of geographical distribution must be reserved until we know more about the inter-relationship of the various genera.

COLUBRINAE.

This sub-family is represented in Madagascar by ten genera, of which four are monotypic and nine peculiar to the Malagasy region; the only genus also found elsewhere is *Polyodontophis*, which occurs in the Indian and Malayan provinces and in Central America. This genus appears to be one of the most primitive of Colubrine genera, and on this account no special significance should be attached to its extended distribution, though its absence from Africa is curious. Another genus *Liopholidophis* is closely related to, or perhaps identical with, *Tropidonotus*. South Africa has 11 genera, of which 10 (*Ablabophis*, *Lamprophis*, *Boodon*, *Lycophidium*, *Simocephalus*, *Pseudaspis*, *Chlorophis*, *Philothamnus*, *Prosymna*, *Homalosoma*), are peculiar to tropical and South Africa; *Tropidonotus laevissimus* (*Grayia lubrica*, *Sclater*) is the only representative in South Africa of its genus, which occurs in all the continents.

* C. W. Andrew's in "Tertiary Vertebrata of Fayum."

† Albany Museum Records, vol. I., p.l.

The precise generic relationship of the genera of the Colubrinae is a difficult problem, for the known important characters are few or uncertain, whilst the different genera mainly represent the numerous comparatively slight variations in the arrangement of the teeth—a character which alone is probably untrustworthy in gauging generic affinities. An important character emphasised by Boulenger is the presence of hypapophyses to the posterior dorsal vertebrae, and several authors have pointed out that the presence of these processes in all the Madagascar colubrines at once separates them from certain American genera to which they had been previously assigned. Nevertheless some American genera do possess these processes, and indeed this character is found in numerous genera distributed in all parts of the world. In South Africa posterior hypapophyses are found in six genera, but in all these genera, with one exception (*Tropidonotus*), the pupil is vertically elliptic, whereas in all the Madagascar genera the pupil is round.

On the other hand, curiously enough, a round pupil is present in all the South African genera, which are devoid of posterior hypapophyses (*Pseudaspis, Chlorophis, Philothamnus, Homalosama*), with the exception of Prosymna. It appears, therefore, that in South Africa the two features of the Madagascar colubrines, presence of posterior hypapophyses and a round pupil, are only to be found combined in one solitary snake, and that, *Tropidonotus laevissimus*, a South African representative of a very widely distributed genus. This is peculiar in view of the fact that these two characters occur together in Colubrines belonging to many parts of the world.

In East Africa a very similar state of affairs obtains, and, judging from the list of species given by Tornier in his Reptiles and Amphibia of German East Africa, 1895, most of the Colubrines of that region are without posterior hypapophyses and the pupil is vertical; and *Tropidonotus olivaceus* is the only species which has at the same time posterior hypapophyses and a round pupil.

It appears, therefore, that all the genera of Madagascar Colubrines have preserved what must be regarded as the more primitive characters the presence of posterior hypapophyses and a round pupil, whilst in Southern Africa none of its peculiar genera have retained both of these characters at the sime time; but this fact has no positive bearing on the question of the generic relationship of these snakes for *a priori* it is quite conceivable that the South African colubrines are immediately descended from forms which were much like the Madagascar colubrines of the present day.

DIPSADOMORPHINAE.

Madagascar has six genera of terrestrial Opisthoglyphous Colubridae, of which five are peculiar to the region, and one genus, *Geodipsas*, with two species in Madagascar, has also a solitary representative in German East Africa. South Africa has the following genera belonging to this group : *Pythonodipsas, Tarbophis,*

Leptodira, Chamaetortus, Amplorhinus, Trimerorhinus, Thelotornis, Rhamphiophis, Dispholidus, Psammophis, Amblyodipsas, Calamelaps, Xenocalamus, Macrelaps, and *Aparallactus;* and 12 out of the fifteen are confined to tropical and South Africa.

One of them, *Leptodira*, occurs also in tropical South America, extending northwards as far as Texas; *Psammophis* extends into Southern Asia as far as Burmah; and *Tarbophis* occurs throughout tropical and N.E. Africa, S.E. Europe and S.W. Asia.

According to Mocquard, four of the Madagascar genera have the posterior hypapophyses distinctly developed (in the B.M. Catalogue another genus (*Eteirodipsas*) is in the same category), whereas only one genus (*Pythonodipsas*) out of 15 recorded from South Africa has these processes.

According to Mr. Boulenger in the B.M. Catalogue, the great majority of the known Opisthoglyphous genera are characterised by an absence of posterior hypapophyses; and such processes occur only in the above-mentioned Madagascar genera, one of which has a representative in East Africa, in a genus peculiar to the Comoro Islands, in one South African genus in a genus peculiar to Socotra, and in a species peculiar to the Philippine Islands.

The monotypic Madagascar genus *Mimophis,* which is without the processes, appears to be most closely related to *Psammophis,* a genus whose headquarters is in Africa, with one or two outlying members in India. These two genera, together with four others, which all belong to the old world, are placed in a distinct subfamily, the Psammophinae.

The above facts rather suggest that the Opisthoglypha are not a natural group, but have been developed along parallel lines from various genera of aglyphous snakes; for whilst the great majority of the Madagascar Colubridae agree together in the possession of these processes, and therefore are probably genetically related, there is nothing to suggest that all the ancestral opisthoglypha elsewhere were similarly endowed. I must mention, however, that according to Nils Rosen* the presence or absence of posterior hypapophyses is by no means a constant character in some species; should this prove to be a fact of general application (which I think is doubtful) the foregoing argument is of course invalid.

RHACHIODONTINAE.

This sub-family comprises only two species, *Dasypeltis scabra,* distributed throughout tropical and Southern Africa, and *D. macrops,* from Cameroon.

ELAPINAE.

The following genera occur in South Africa: *Elapechis, Naia, Sepedon, Aspidelaps, Homorelaps* and *Dendraspis;* these genera, Naia only excepted, are peculiar to Tropical and South Africa. The genus *Naia* occurs throughout Africa and Southern Asia, extending to China and the Malay Archipelago. So far as can

* A.M.N.H., 7, 16, p. 126.

bé judged from their external characters, these genera do not form any characteristically African association, but *Dendraspis* has the rank of a distinct section.

VIPERINAE.

South Africa has the following genera: *Causus, Bitis, Atractaspis* and *Vipera,* the first three being confined to tropical and South Africa, though *Bitis arietans* extends to Morocco and Arabia. Causus and Atractaspis are each isolated and peculiar genera, whilst *Bitis* is related to *Vipera,* whose headquarters are in Europe, with an odd species in Mozambique and another in India and Ceylon. The genera *Bitis* and *Vipera* belong to a section of Vipers which includes also *Pseudocerastes* (of Persia), *Cerastes* (North Africa, Palestine and Arabia), *Echis* (one species common to Northern Africa, Arabia and India, the other species occurring in Palestine and Arabia) and *Atheris* (tropical Africa).

Dr. Gadow has suggested that the Viperidae do not constitute a natural group, and certainly the South African genera, superficially at any rate, seem so different that it may well be that the Viperine character is a result of convergent evolution. Judging from the distribution of the more typical Viperine genera, *Bitis* came from the North; on the other hand the peculiar genera *Causus* and *Atractaspis* may have developed in Africa from some local opisthoglyphous snakes, but this speculation requires confirmation from anatomists.

CONCLUSIONS.

We are not able to fully interpret the facts of present day distribution owing to our scanty knowledge of phylo-genetic relationship. From the facts now available there could be little reason to suspect that the ophidian fauna of South Africa is of dual origin, for the more specialised sections of the Colubridae seem to be for the most part just as peculiar to the area as are the more generalised sections, and no doubt the final differentiation of such genera as *Sepedon, Aspidelaps* and *Dendraspis* has taken place in Southern Africa; but to what extent the ancestral viperine and proteroglyphous stock is of external origin or of local ancestry must remain a matter for future discovery. However, as there appears to be some indications amongst the Colubridae of an affinity with the Madagascar fauna, it is easy to see that the known facts are in general harmony with those relating to the lizard faunas of South Africa and Madagascar; premising which, the fact that both areas are inhabited by numerous snakes, which we are obliged to refer to so many peculiar and distinct genera merely proves that the differentiation of these Colubrine genera has taken place subsequently to the separation of Madagascar from Africa.

Again, the genera *Glauconia* and *Leptodira* furnish good evidence in favour of a direct land connection between S. America and Africa since the period of origin of those genera, that is to say probably during early tertiary times. Indeed, in view of the

distribution of *Leptodira* it would appear quite probable that the new world *Opisthoglypha* originally came from the Ethiopian region, the broad facts of the case being that this sub-family occurs throughout Africa, Madagascar and the Indian region, but in the new world, although their centre is in South and Central America, none of them occur in the Antilles, which islands were in extensive land connection with Central America during Miocene times (Gadow in P. Z. S., 1905, 236); the fauna of the greater Antilles in fact includes only Typhlopidae, Boidae and Aglyphous Colubrines. Parallel facts of distribution obtain for the Proteroglypha, and on the other hand in both these higher groups of Colubridae we have seen that there is an element in common with the Indian region; the absence of *Proteroglypha* from Madagascar implies, in terms of our theory, that the connection between East Africa and the Indian region was in existence after the isolation of Madgascar.

WITHANIA SOMNIFERA. Messrs. Power and Salway recently communicated to the Chemical Society (London) results of an investigation into the chemical constituents of *Withania Somnifera* Dunal, obtained by them from South Africa. An alkaloid was found to be present both in the roots as well as in the upper portions of the plant, and several other new compounds were also met with. An amorphous alkaloidal principle was obtained from the root: this, on treating with alkali hydroxides yielded a crystalline base of composition $C_{12} H_{16} O_2$. The roots further yielded a monohydric alcohol, withaniol, and another monohydric alcohol, somnirol, was procured from the leaves and stems, as well as a dihydric alcohol, somnitol, and an acid, withanic acid. Physiological tests, conducted on a dog, failed to confirm the plant's reputed sedative or hypnotic properties.

CAPE GEOLOGY.—At a meeting of the Geological Society (London) held on the 22nd February, Mr. R. H. Rastall described the physiography and geology of the Worcester, Robertson, and Ashton districts of the Cape Province. A detailed account, as to structure and character of the rocks of the Malmesbury series in the vicinity was given. Mention was made of the phyllite gneiss, formed by the crushing and foliation of the intrusive granite in the upper members of the series, bringing about the metamorphosis of limestone bands into the well-known white marble of Worcester. The occurrences of the Enon Conglomerate were described, and the opinion was expressed that the great Worcester-Swellendam Fault, with its throw of about 10,000 feet, is in great part of Post-Cretaceous age. The fault is assumed to be a line of fracture and subsidence transversely across the lines of folding of two great sets of folds, at right angles to each other, which impart to the adjacent areas their fan-shaped plan.

THE LIGHTING OF INTERIORS.

By Prof. H. Bohle, M.I.E.E.

The advent of the metal filament lamp has greatly altered the methods for lighting the interiors of buildings. The high candle power incandescent lamp is rapidly driving out the arc lamp, since lighting with the former is cheaper and more convenient than with the latter. Cheaper if we take re-carboning and attention into account, and more convenient since the glow lamp largely looks after itself.

For interiors flame arcs are not yet a complete success. The fumes given off by these lamps are objectionable, and the light is far too concentrated. Moreover, if one takes into account the troubles which are connected with these arc lamps, and the amount of attention they require, it will be found that, even for street lighting, the saving when using flame arcs, compared with metal filament lamps of the Tungsten type, is not very great. The polar curves, which are very often submitted by the makers of these lamps, frequently give higher candle powers than the values determined by impartial tests. I do not think that the arc lamp will, in future, be very much employed except for large squares and very broad streets.

As regards Interior Lighting, let us first consider the amount of light required (1) for direct lighting, and (2) for Indirect Lighting.

DIRECT LIGHTING.

In order to determine the quantity of light for different localities, I carried out a number of experiments in reading the ordinary type of text-book print in rooms of different colours. The values, given in Table I., are actually the mean values of a number of observations by different observers.

Table I.

ILLUMINATION REQUIRED FOR READING IN ROOMS OF DIFFERENT COLOURS.

Colour.	Illumination in Candle metres (British Candles).
Black room	35
Deep red	32
Dark green	30
Pale blue	28
Light yellow	25
Cream silvery	23
White	20
White (indirect light)	15

This table holds for distributed light, the maximum illumination of which is not more than 40 per cent. greater than the mean. It should further be mentioned that the table has been plotted with regard to equal comfort in all cases. This implies, however, that the eye should roam as little as possible from the print, in the rooms of the darker colours, otherwise it becomes more tired with the higher illumination than with the lower one. In the latter case contrast is almost entirely avoided, and it is to this that the eye objects.

The divergency in the above table may be explained as follows :

In the darker room, on looking at the print, the aperture of the pupil becomes set to a certain width as long as one does not move the eye away from the book. At the same time one has the feeling of surrounding blackness, and the great contrasts prevailing make the eye roam instinctively. As soon, however, as the eye encounters the darkness the pupil extends. In the next instant the eye again strikes the brilliantly illuminated paper, and consequently the pupil contracts, and probably more than is necessary, because it experiences a glare. But too much contraction makes the illumination appear insufficient, and the pupil expands again. This repeated expansion and contraction seem to make a higher illumination necessary.

The table shows us that the least illumination is required when the illumination is approximately uniform, as obtained from inverted lamps. In reversing the lights of a lecture room, so as to obtain indirect illumination by reflecting the light from the ceiling, the actual illumination was reduced from 23 to 12 (average) candle metres. Yet, the students were highly delighted with the new arrangement and preferred it to the former method. For drawing and writing purposes it was certainly preferable, because shadows were almost completely avoided, a thing which cannot be prevented with direct lighting, no matter how well the lamps are distributed. Pronounced shadows are, however, very irritating, especially if they fall in the wrong place. It will also be found that the values of the above table become insufficient if the light is badly distributed, an increase of 10 or 12 per cent. being necessary when the maximum value is double the mean value.

There is no doubt that the eye is far more dependent upon contrasts than upon actual values. A lamp which will cause glare at night will often not do so during the day, and if one walks from the sunshine into a brilliantly artificially lighted room, the latter nevertheless appears very dark. Contrasts in artificial lighting are easily avoided if we paint the room white or with light yellow colours. Not only do we require less illumination in rooms of light colours, but less light will give a better illumination on account of the reflection of light from the walls and ceiling.

The quantity of the reflected light depends largely upon (a)

the colour of the surroundings, (b) the height of the illuminants above the plane in which the light is tested, and (c) somewhat on the size of the room. Numerous tests were made in a room measuring 10 metres by 6½ metres, having thus an area of 65 square metres. The lamps were arranged according to Fig. 1., in such a way that they could easily be placed at different heights.

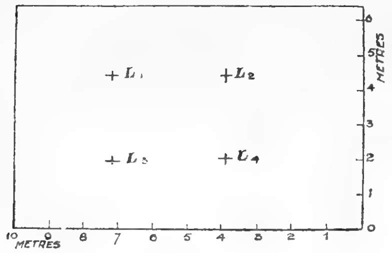


Fig. 1.

They were tested first with metal shades, enamelled white, and then without shades. The room had a white ceiling and light yellow walls, but the paint was not new, though in fair condition. The lower portion—about 1.2 metres high—was painted a dark green, but this had little influence on the reflection, as the horizontal test plane was placed one metre above the floor. The average diffused reflection co-efficient of the room with all the furniture was approximately 0.5, as nearly as it could be determined.

The light was tested by means of an illumination photometer of fair accuracy along the middle of the room and along its sides, and the average taken. Next the illumination was calculated from the polar-curves of the lamps, taking into account the illumination due to all the lamps in the room (4). Siemen's one watt Tungsten lamps were used, with polar-curves as shown in Fig. 2.

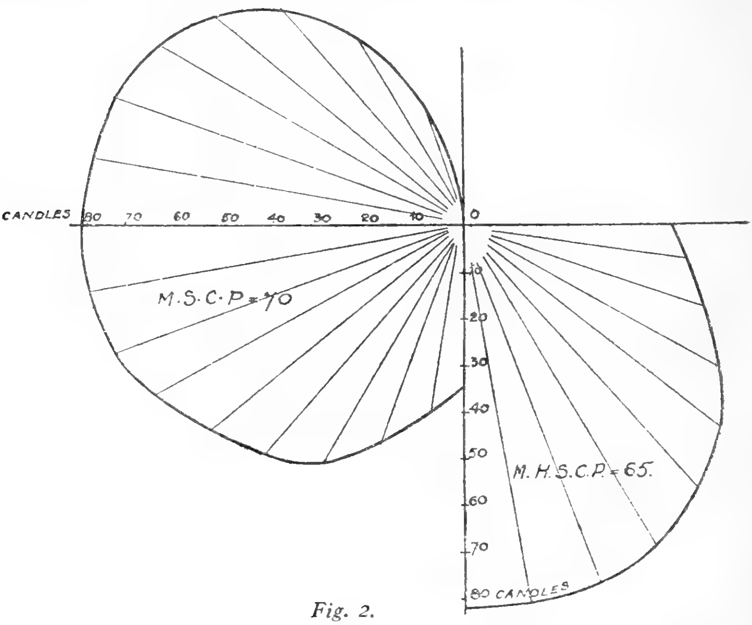


Fig. 2.

In Fig. 3 are shown two curves as calculated and as determined with the instrument. The average values were then got, and plotted as function of the height of the lamps above the testing plane.

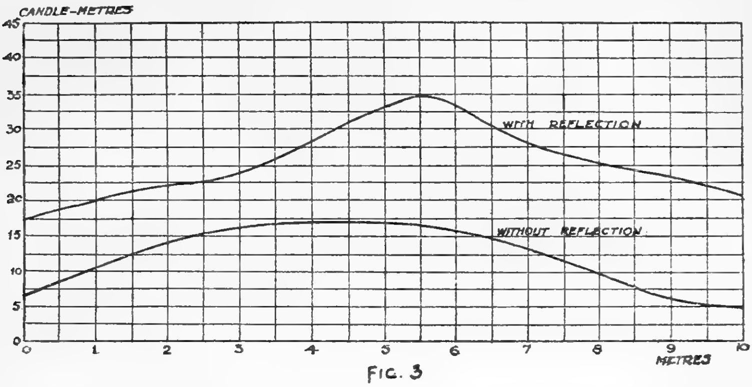


FIG. 3

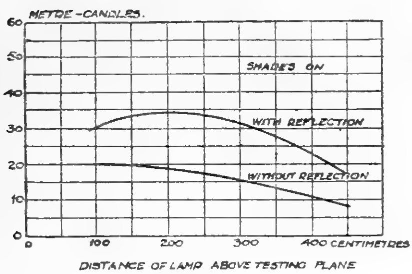


FIG. 4

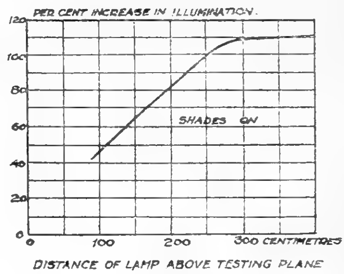


FIG. 5

The results are plotted in Fig. 4. From the latter follows Fig. 5, which clearly shows that the amount of reflected light varies enormously with the position of the lamps.

The tests were repeated, with the shades off the lamps. The results are plotted in Fig. 6, from which follows Fig. 7. We see

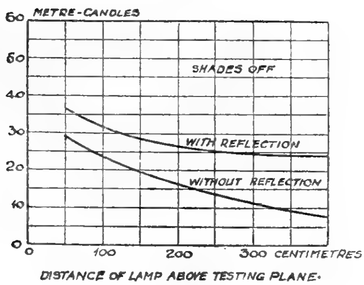


Fig. 6.

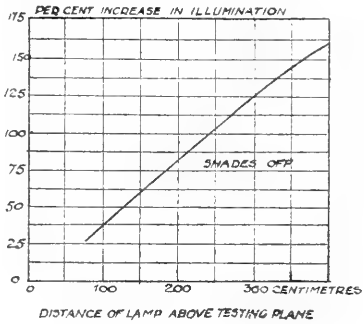


Fig. 7.

that the amount of light due to reflection is considerably greater. than before, because the ceiling now takes part in the reflection.

In Figs. 8 and 9 are plotted the ratios $\frac{\text{Max illumination}}{\text{Mean illumination}}$ against the positions of the lamps. We see that by passing from the dark room to the one with light yellow walls, we increase the uniformity considerably.

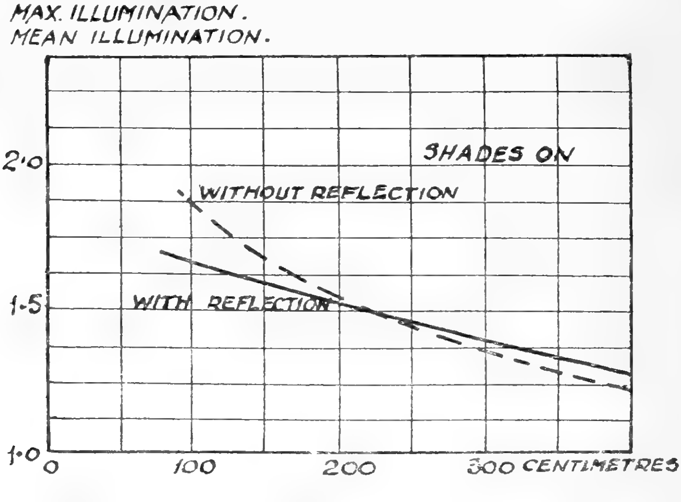


FIG. 8

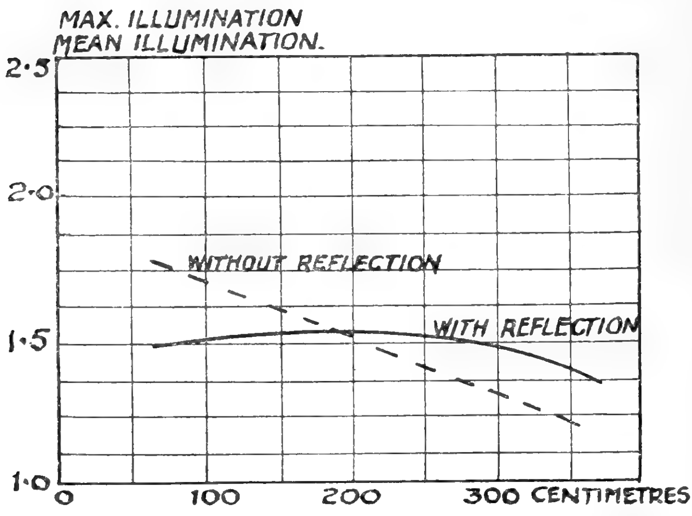


FIG. 9

With the aid of the results so far obtained we can now find the percentage increase in the illumination for rooms of other colours, as long as we know the co-efficients of diffuse reflection for these colours. We then get Fig. 10. If we assume the same room as before and the same lamps, Fig. 10 is for lamps with shades on and Fig. 11 with shades off.

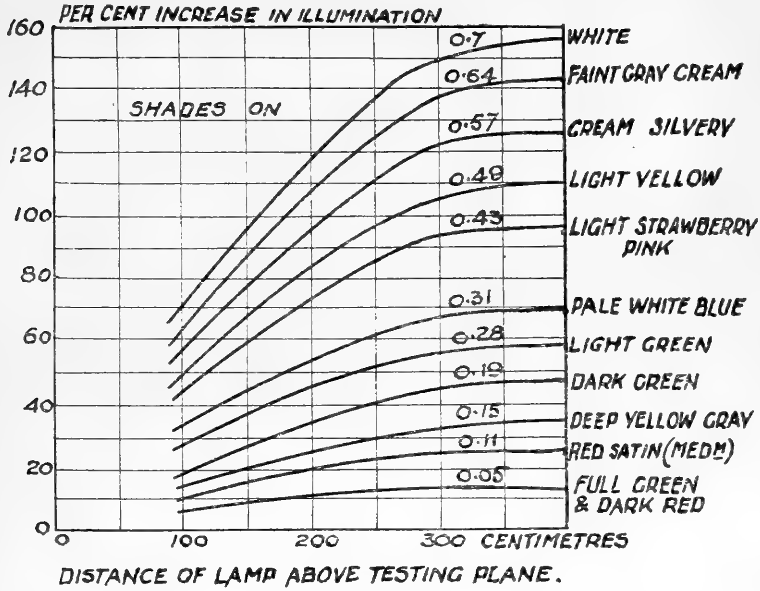


Fig. 10.

Fig. 11 has been plotted for four colours only, as one would hardly use lamps without shades in rooms with dark colours. The co-efficients of diffuse reflection have been inserted in the figures.* In checking the results in two actual rooms with similar wall-papers, for which Bell determined the co-efficients, a good agreement was found to exist. The furniture, however, was completely cleared out. The value depends also on the size of the room.

With the results obtained we are now able to predetermine for any given room and colour the candle power necessary, giving results of Table I. as average values. The candle power per square metre surface (mean hemispherical) for lights with conical opaque shades, has been plotted as functions of the height of the lamps above the testing plane. The average value depends comparatively little on the distribution of the lamps, but the uniformity is greatly affected thereby. The effect that with great uniformity less light is required, has been neglected in Fig. 12.

* See Dr. Louis Bell, *Illuminating Engineer*, March, 1908.

Without shades, if taking into account the mean spherical candle power of the lamp we get Fig. 13.

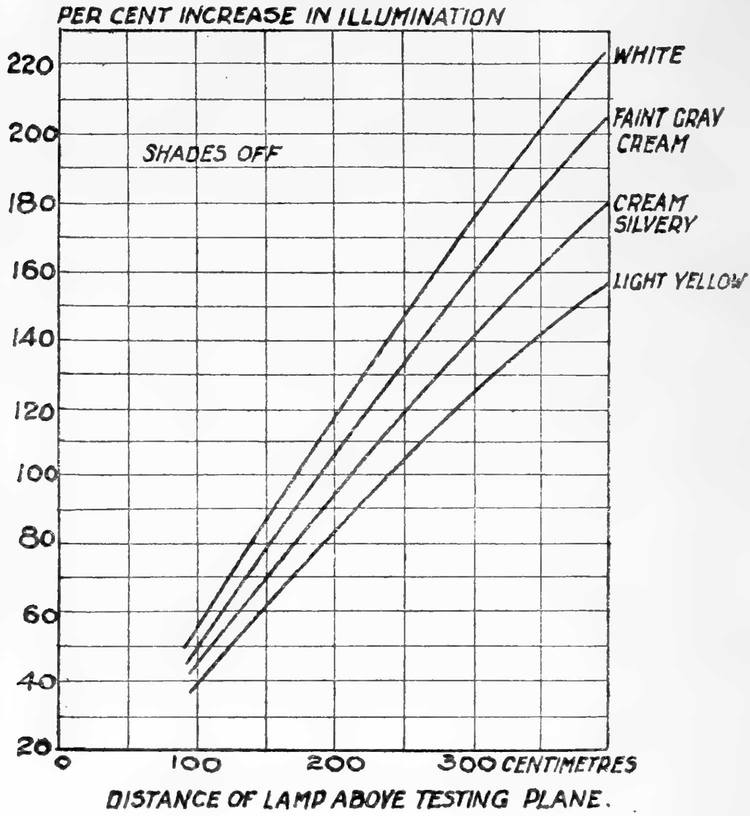


Fig. 11.

The figures given in these curves hold, of course, strictly speaking, only for a particular room, but experiments tell me that they can be used with fair accuracy for any other room with distributed lights.

Example.—We are asked to fit up a room with a floor space of 100 sq. metres, with electric light so as to give an average illumination of 25 candle-metres. The walls are light yellow. From Fig. 12 it follows that per square metre surface we require 3.2 candles if the lamps are fixed 200 cms. above the testing plane, or 3 metres above the floor. For any other illumination or height of lamps, the light can be easily determined.

INDIRECT LIGHTING.

In the tests the same room was used; also the same lamps and shades, which were simply reversed. The illumination depended

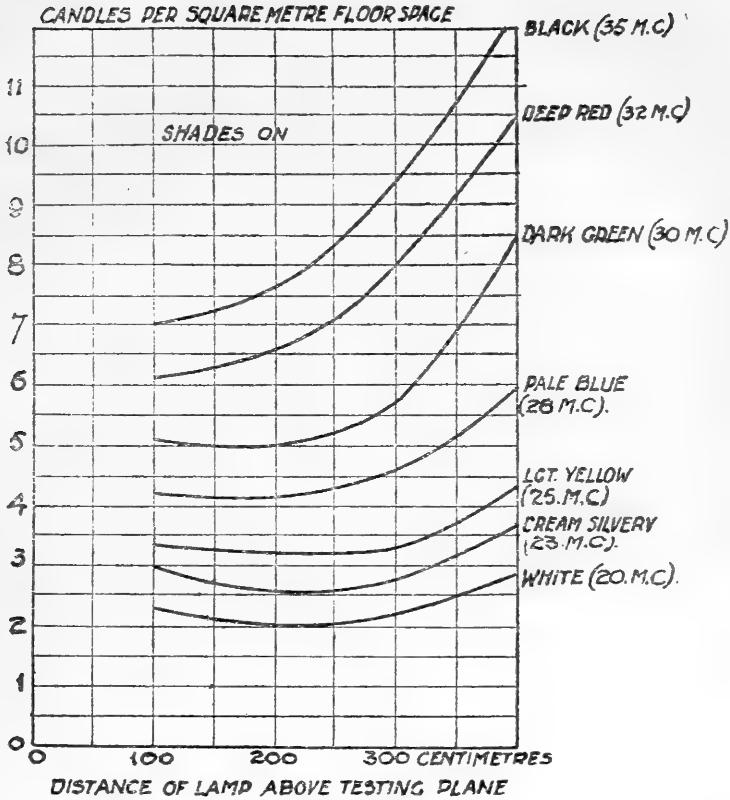

CANDLES PER SQUARE METRE FLOOR SPACE
SHADES ON
BLACK (35 M.C)
DEEP RED (32 M.C)
DARK GREEN (30 M.C)
PALE BLUE (28 M.C).
LGT. YELLOW (25.M.C)
CREAM SILVERY (23 M.C).
WHITE (20.M.C).
0
1
2
3
4
5
6
7
8
9
10
11
0
100
200
300 CENTIMETRES
DISTANCE OF LAMP ABOVE TESTING PLANE

Fig. 12.

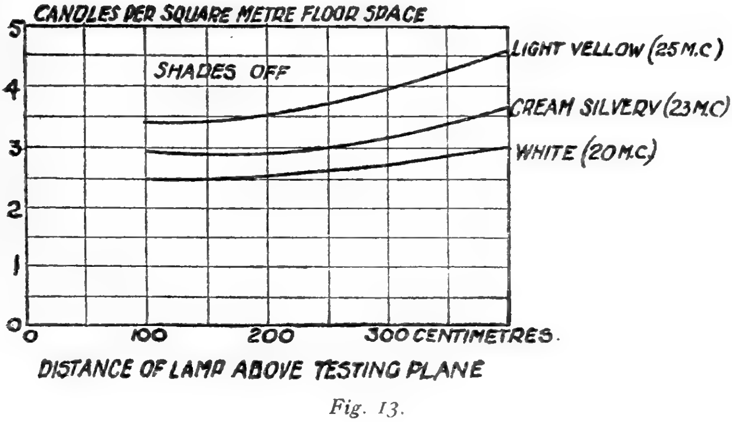

CANDLES PER SQUARE METRE FLOOR SPACE
SHADES OFF
LIGHT YELLOW (25 M.C)
CREAM SILVERY (23 M.C)
WHITE (20 M.C)
0
1
2
3
4
5
0
100
200
300 CENTIMETRES.
DISTANCE OF LAMP ABOVE TESTING PLANE

Fig. 13.

largely upon the distance of the lamps from the reflecting ceiling. The results are illustrated in Fig. 14. We get the best results when the distance of the centre of the lamp is 75 cms. from the ceiling. The ordinates of the curve represent average values. Fourteen candle metres gave results entirely satisfactory. Shadows almost disappeared, and the result was highly pleasing. The lamps used were four Tungsten one watt lamps of 65 mean hemispherical candle power, so that with inverted lamps, fixed at the best distance from the ceiling—a distance depending on the type of shade and the reflector employed—we require for a mean illumination of 15 candle metres in a room with very light yellow walls and a white ceiling, approximately $4 \times \frac{15}{24} = 4.3$ British candles per square metre floor space. For white walls this reduces to approximately four candles for the same illumination. If the reflection takes place not from the ceiling but from special reflectors, in places where the ceiling is painted a dark colour, where the walls are also of a dark tint, more light is required to ensure the same comfort. One would, however, hardly employ inverted lamps in rooms with walls painted in dark colours. The writer intends to carry out further experiments in connection with inverted lighting. At present it may be mentioned that better

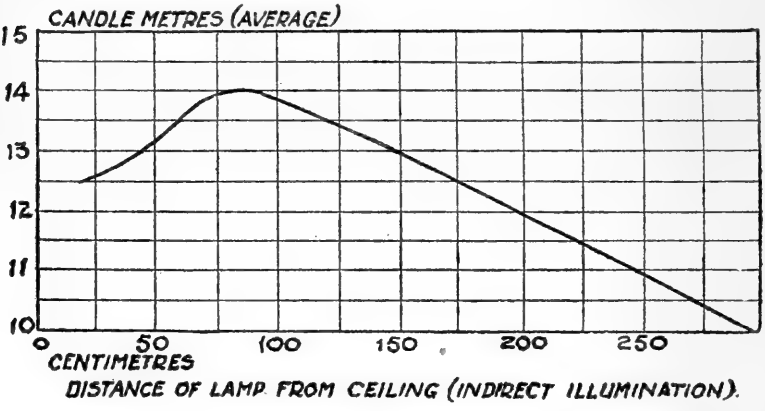


Fig. 14.

results are obtained if the reflector below the lamps is perfectly opaque, than with a shade which allows part of the light to pass through. The difference between two shades of identical shape, one opaque and the other semi-transparent, amounted to about 14 per cent.

In conclusion, I should like to point out again that the results given in this paper must be considered as only approximately correct. In lighting it is impossible to lay down rules holding in all cases, and one must rely on experience. The experiments, however, should be of some use, when the planning of new buildings takes place. In the writer's opinion inverted light is used far too little, because it is considered too expensive. In reality

it is but little dearer than direct lighting, if the latter is carried out properly. We certainly obtain less illumination than in the direct way, but the greater uniformity requires also a good deal less; and, the nearer artificial conditions approach more natural ones, the greater is the resulting comfort. With properly diffused artificial light, the eyesight of the human race would be materially improved.

The tests were carried out with conical opaque shades. The results will, however, be little different with other shades, *i.e.*, as far as the average values are concerned, except as regards the uniformity. The conical shape gives results slightly better than the holophane glass globe, which comes next in a set of six different kinds of shades tested.

ELECTROTECHNICAL COMMISSION.—At the St. Louis Electrical Congress of 1904 the formation of an International Electrotechnical Commission was resolved on, and a preliminary meeting was held in London in 1906, when the Commission was practically constituted, Lord Kelvin being elected its first President. The first Council meeting, held two years later, nominated Prof. Elihu Thomson as President, and a full meeting of the Commission is to take place at Turin during the latter half of 1911. Electrotechnical Committees have been established in sixteen countries, and in most cases these receive the financial support of their respective Governments. In eight other countries, including South Africa, similar committees are either in process of formation or likely to be formed.

TRANSACTIONS OF SOCIETIES.

SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS.—Thursday, February 9th: J. H. Rider, V.P.I.E.E., President, in the chair.—Presidential address: J. H. **Rider.**—The President briefly referred to the aims, objects, and functions of the Institute.

GEOLOGICAL SOCIETY OF SOUTH AFRICA.—Monday, January 30th: Prof. R. B. Young, M.A., B.Sc., F.R.S.E., F.G.S., President, in the chair.—"The problem of the Rand banket," Presidential address: Prof. R. B. **Young.** The banket is generally agreed to be a littoral marine deposit, conspicuously affected by cementation since its deposition, subjected to considerable strain, and influenced by numerous igneous intrusions. The presence and form of pyrite in the rock is difficult of explanation, whether the placer or infiltration theory be adopted. In any case it is probable that solution and reprecipitation of pyrite throughout the rock had occurred. The gold in the rock assumes the identical forms as in quartz veins. The carbon present is essentially the same as anthracite, and has evidently been precipitated from some liquid which had penetrated the rock's minutest cracks. In the author's opinion that form of the infiltration theory which makes the precipitation of the gold to depend on chemical rather than on physical causes is to be preferred.

Monday, February 13th: Dr. E. T. Mellor, F.G.S., **President**, in the chair.—"Amygdaloidal epidiorite, Bulawayo": A. E. V. **Zealley.** A description of a variety of hornblende rock which occurs extensively in some parts of Rhodesia. The amygdaloidal character is boldly developed, and the author believes that the series originated as a lava flow.—"The diamond-bearing deposits of Bagagem and Agua Suja in the State of Minas Geraes, Brazil": D. **Draper.** Descriptive notes of the mineralogy and geological structure of the areas mentioned.

Royal Society of South Africa.—Wednesday, March 15th: Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S., Vice President, in the chair.—"Sylvester's and other unisignants": Dr. T. **Muir.** The author endeavoured to throw fresh light on Sylvester's work by bringing it into the same field of view with recent investigations of a more general character.—"The fourth order perturbations in the motions of Satellites III. and IV. of Jupiter": R. T. A. **Innes.** A recomputation of long-period inequalities in the longitude of the third great satellite of Jupiter, and a computation—for the first time—of inequalities in the motion of satellite IV.—"The funeral ceremonies of the Hottentots": C. L. **Biden.** Descriptive of the practices of native medicine men during illness of a patient, and of the customs carried on during the weeks following upon a fatal termination.—"The meteorites in the Bloemfontein Museum": Prof. W. A. D. **Rudge.** Descriptions of the Kroonstad (1877) and Winburg (1881) meteorites. The former consists of a fibrous mass of iron-nickel alloy, the latter contains 94 per cent. of iron and 2 per cent. of nickel, the nickel being confined to veins which intersect the mass. The nickel-iron alloy is magnetic and remains so up to a dull red heat.—"Seismographic record of the South African earthquake of October, 1910": Dr. J. R. **Sutton.** The horizontal pendulum moved over an extent equal to half its average daily E.W. oscillation.—"Collodial gold and Purple of Cassius": Dr. J. **Moir.** Behaviour of chlorauric acid solution (1:200,000) towards a number of reducing agents. Colloidal aurous chloride, which is of a brown colour, seems to be formed when pure stannous chloride is added, and purple of Cassius only when an oxidising substance with loosely bound oxygen is employed.—"Some remarkable oxidation products of Benzidine": Dr. J. **Moir** An investigation of the blue products obtained from benzidine by certain oxidation processes.—"The Egyptian influence of Rhodesia ruin builders, or *vice versa*": H. W. **Tarbutt.** The author considers the native origin of the Rhodesian ruins not improbable, if the articles found are compared with those of Egyptian primitive art. Such resemblance the author thinks are almost unvarying.

South African Institute of Engineers.—Saturday, March 11th: J. A. Vaughan, President, in the chair.—"Ore Bin Design": N. Y. **Robertson.** The author indicated how, by means of a graph, the weight of ore accommodated in a standard bin of specified height could be readily determined, and then proceeded to investigate the pressures on the vertical and inclined members of such a bin.

Chemical, Metallurgical, and Mining Society of South Africa.—Saturday, March 18th: Dr. J. Moir, M.A., F.C.S., President, in the chair.—"The amalgamation of gold in Banket ore": W. R. **Dowling.** The history of amalgamation recovery since the early days of the Witwatersrand gold mines was traced, and the necessity or advisability was discussed of amalgamating the final pulp leaving the crushing plant as an overflow of the tube-mill classifiers.—"Air lift agitation of slime pulp": R. **Allen.** An account of the development of methods for agitating slime pulp by means of compressed air, and of the application of air-lift apparatus on the Transvaal mines.

South African Society of Civil Engineers.—Wednesday, April 12th: Col. G. T. Nicholson, M.I.C.E., President, in the chair.—"Notes on the maintenance of Permanent way": W. G. **Cocks.**

DETERMINATION OF THE PLACES OF THE PLANETS.

By Robert T. A. Innes, F.R.A.S., F.R.S.E.

In the *Observatory* for September 1910, Professor H. H. Turner, F.R.S., of the University Observatory, Oxford, puts forth proposals for measuring large arcs of the sky (say about 90° or 120°) by means of two fixed horizontal telescopes and a mirror. The places of the heavenly bodies are at present referred to the sphere by means of Right Ascensions measured along the equator of the sky from the spring equinox (first point of Aries) and Declinations measured from the equator towards each pole. The Declinations depend on simple angular measurements made with divided circles. Although such measurements are comparatively simple, there are subtle difficulties well-known to the practical astronomer which Professor Turner duly notes. The angles involved in the Right Ascensions are measured in quite a different way. Advantage is taken of the rotation of the Earth. Each star will roughly transit the meridian once in 24 sidereal hours; hence if one star transits at say noon and another 12 hours later, we know that they are separated in Right Ascension by half a circumference or 180°. This method is simple enough; the difficulties arise from the fact that during sunlight, the stars are invisible, or if the stars are bright enough to be seen, they are observed under different conditions of temperature from those observed at night, and we can only tell when 12 hours have elapsed by means of clocks which suffer more or less from temperature effects; again to find the spring equinox or zero-point of the Right Ascensions, it is necessary to find the Sun's position amongst the stars. These difficulties become very great in practice, and it is considered that all stars' Right Ascensions suffer from errors of the type

$$A \, sin \, R.A. + B \, cos \, R.A.$$

If Professor Turner's proposals can be carried into effect, it should be possible to eliminate errors of time-keeping, but the great practical difficulty of referring the Sun to the stars will always remain. Professor Turner has expressed his willingness to essay his new ideas, and we hope that means will be at hand to enable him to do so.

I believe the late Monsieur Loewy endeavoured to use the bent-equatorial of the Paris Observatory with an object-glass prism in somewhat the same way, the ostensible object being the determination of the constant of aberration; but the results, if any, are unknown to the writer.

Professor Turner's proposals have led me to a vein of thought which is worked in what follows.

As just mentioned the Right Ascensions of the heavenly bodies are determined by the rotation of the Earth. Is this the right way, and what would happen, as is alleged to be the cases with the neighbouring planets Venus and Mercury, if the Earth did not rotate with reference to the Sun? If the Earth rotated very slowly or not at all the precise measurement of time would become exceedingly difficult if not actually impossible. The Sun would remain fixed in the sky within a line less than 4° long, along which

it would vibrate once a year. Assuming the Earth rotated to the Sun in the way the Moon does to the Earth, *viz.*, once in a revolution, the stars would move around our sphere not once in 24 hours but once a year and the transit instrument of an observatory would be well-nigh useless. Such an Earth would have neither equators or poles. The chief celestial circle would be the ecliptic, but the difficulty of referring the Sun to the stars would be enormous and would probably be far beyond either the inductive or deductive power of the strongest human intellect.* The climatic consequences of non-rotation would also be extraordinary, but need not be dwelt on here. At first, the best timekeeper (but a very irregular one) would be the Moon. If the Earth's rotation were now decreasing and the rotation finally ceased, the perfection of astronomy would permit us to continue exact time-keeping by means of :—

(1) The eclipses or motion of the 1st Satellite of Jupiter whose period is about 42 hours;

(2) The motions of some of the satellites of Saturn.

(3) The variations of light of the very short period variable stars;

(4) The movement of the Moon, once its theory is perfected.

The peculiar principle of using the rotation of the Earth for angular measurements introduces another consideration. Let it be assumed that time cannot be determined by an astronomical observation within one-tenth of a second,—in this time the Earth has described an angle of $1''.5$; if, however, the Earth rotated in 48 hours instead of 24 hours, the angle would be $0''.75$; if in 9 hours 55 minutes (the time of rotation of Jupiter) the angle would be $3''.7$. Hence the anomalous result that the quicker our measure of time, the greater the resulting error of a star's place. There is another way of looking at the question: still assuming that the uncertainty of a time determination is one-tenth of a second (which is somewhat greater than is the case in well-equipped observatories) the resulting place-error will be uncertain to $1''.5$. This arc is passed over by the mean-motions of the various planets in the following times :—

Mercury	9	seconds.
Venus	23	,,
Earth	36	,,
Mars	69	,,
Jupiter	7	minutes.
Saturn	18	,,
Uranus	50	,,
Neptune	100	,,

* If the Earth's rotation is now decreasing and ultimately becomes equal in length to the solar year, astronomers with their accumulated konwledge would be prepared, their theories would still be valid; the words "far beyond . . . the power of the . . . intellect" refer to a previous stage of human history. Had the Sun been virtually fixed in the sky at the dawn of civilization, the difficulty of interpreting phenomena in terms of time would have been so great that the chances of a solution or explanation on the present lines would be negligible. If in addition, the skies were cloud-laden, as is the case on the planet Venus, the development of ideas of the universe would be entirely different. The supposed human inhabitant on Venus can have no knowledge of matter apart from his own planet—his universe extends to the height of the clouds and no further.

This little table shows that if we can fix the time of transit, say of Uranus, to a tenth of a second, which, be it noted, represents no longer actual time, but angular measure of Right Ascension, we have only found the place it really occupies with an uncertainty of some 50 minutes of time. This shows the weakness of using the rotation of the Earth as a means of fixing the positions of the heavenly bodies. The difficulty cannot be entirely overcome as long as our time is based on the rotation of the Earth and the motion of the Sun amongst the stars, as is the case at present. But the fixed stars move so very slowly, as indeed the word "fixed" indicates, that it is possible to obtain their positions with a precision which is at least 10 times greater than the exactitude in determining the position of a planet on the meridian. Astronomers attempt to use this exactitude by adopting other means of observation, such as the heliometric measures of the angular distances of planets from fixed stars which was extensively tried under Sir David Gill's direction at the Cape Observatory, or by means of photographs, by which the planets can be referred to the neighbouring stars, a means extensively used at the Greenwich Observatory. The convenience of the photographic method is so great that it will ultimately prevail and the exactitude will be very great, but at the present time the places of the comparison stars are in general not very well-known. The progress of the Carte-du-Ciel catalogue will in time remedy this defect. If the observation of a planet occulting a bright star is carefully recorded, it will yield the place of the planet at a given second of time with all the precision of the star-place itself.

The determination of the Moon's place by meridian-passages is subject to difficulty, insomuch that it is the rough illuminated limb which has to be observed. The error of a meridian lunar observation is at least three seconds of arc corresponding to about 6 seconds of time, so that if the star's place is well-known and the occultation has been well-observed, the Moon's place should be found within $0''.1$. As several occultations can be observed on one evening by several observatories working in co-operation, it should be possible to attain this accuracy, but again with the proviso that the stars' places were known to that degree of precision and this is only the case with a few of the brighter stars. It therefore appears to the writer that the principle of using the Earth's rotation as a means of angular measurement should be used as sparingly as possible.

Star places should be found by means of photographic plates, which should be referred to each other by angular measurements, such as advocated by Professor Turner. The angular measurement due to the rotation of the Earth would then only be required for finding the position of the Sun amongst the stars.

As a star's Right Ascension and Declination are always changing through the precession, whilst the stars themselves are almost "fixed," it is obvious that this choice of co-ordinates is an unfor-

tunate one. There are three sets of co-ordinates which appear to be possible :

(1) The Ecliptic;
(2) The invariable plane of the solar system;
(3) The plane of the Milky Way.

But in each case it would be necessary to adopt a fixed departure point. In the case of (3) probably either the intersection of the invariable-plane with the Milky Way or the plane of the solar drift (apex and antiapex) would furnish such a point. In any case the departure-point could be fixed so that the resultant proper motions in the adopted plane of say 1,000 bright stars should vanish. If (1) were adopted, in the course of 30,000 to 100,000 years the latitudes of the stars would vary by possibly 2 degrees or so; but if (2) or (3) were adopted the stars' places would only change by proper motion. If alternatives (2) or (3) were adopted, it would mean the computation once and for all (or at least for say 1,000 years) of some 250,000 star-places, and in addition the moving co-ordinates, *i.e.*, Right Ascension and Declination of about 1,000 stars. The labour thus saved would be enormous. A very large part of the time of every observatory is devoted to bringing star-places up-to-date,—this labour is never-ceasing; on the contrary it tends to augment.

It can be safely said that had the great astronomers Lacaille, Lalande, Piazzi and Bessel, to whom we are indebted for the earliest extensive catalogues of faint stars, been in possession of the photographic dry-plate, their catalogues would not have been based on Right Ascensions and Declinations.

INTERNATIONAL GEOGRAPHICAL CONGRESS —Preparations for the tenth International Geographical Congress, to be held in Rome under the patronage of the King of Italy during the week beginning October 15th, are now in active progress under the direction of an Organising Committee appointed by the Council of the Italian Geographical Society. The Congress will be divided into the following eight sections :—Mathematical geography, Physical geography, Biogeography, Anthropogeography, and ethnography, Economic geography, Chorography, Historical geography, and History of geography, Methodology and Didactics. Buildings have been specially erected for the accommodation of the Congress in the grounds adjacent to Castel Sant'Angelo, where the inaugural meeting will take place on the date above mentioned. There will be some excursions in the neighbourhood of Rome during the course of the Congress, and immediately after its conclusion there is to be an excursion into Central and Northern Italy, in order to visit regions where geographical factors have caused particular economic and industrial development, and another in Southern Italy and Sicily, where most interestic geologic and volcanic phenomena, including the ravages of the 1908 earthquake, may be observed.

ACETYLENE AS A HEATING AGENT IN CHEMICAL LABORATORIES.

By Prof. BERTHAULT DE ST. JEAN VAN DER RIET, Ph.D., M.A.

(*Abstract.*)

The author gave some demonstrations of acetylene flames used for heating purposes, the gas being supplied from a generator placed at his disposal by Messrs. Hofmeyr, du Toit and Duffett, of Cape Town.

It was pointed out that acetylene can be used with advantage in Laboratories where coal gas cannot be obtained.

On account of the great heat of its flame however, special precautions have to be taken—wire gauze to be protected by asbestos, and glass vessels cautiously heated. Moreover platinum vessels are apt to become brittle if heated in the most reducing part of the flame. Instead of using acetylene alone it is possible to modify the nature of the flame considerably by the admixture of a small proportion of gasoline (petrol) vapour. The flame then does not 'strike back' as easily and the gas may be used under a pressure of only three inches of water, whereas when pure acetylene is used the colourless flame is best obtained when the pressure is equal to ten inches of water. This use of gas under comparatively high pressure has certain disadvantages—such as greater leakage, back flow of air into tubes when gas is turned off at night and the like—so that the use of petrol-acetylene has a good deal to commend it.

SANITARY DWELLINGS.—The third International Congress of Sanitary Dwellings is appointed to be held at Dresden from the 2nd to the 7th October, 1911. The Congress has for its object the scientific advancement of hygiene and sanitation: its work on this occasion will be distributed amongst the following nine sections:—(1) *Town planning;* building, forms of country settlement, garden cities, width of streets, height of buildings: (2) *Construction of buildings;* planning, distribution of space, building material, foundations, basement, kitchens, lavatories, floors and ceilings, staircases, lifts and roofs: (3) *Internal arrangements;* lighting, heating, ventilation, furnishing: (4) *Sanitation;* cleaning, removal of refuse, disinfection: (5) *Dwelling-houses in towns:* (6) *Dwelling-houses in the country:* (7) *Public buildings;* school buildings, boarding schools, prisons, hotels, lodging houses, hospitals, convalescent homes, baths, churches, theatres: (8) *Workrooms and workshops; means of communication and transit;* railways, tramways, ships, vehicles: (9) *Legislation, executive, statistics.*

NOTES ON THE GEOLOGICAL FORMATION OF PORTIONS OF GERMAN SOUTH-WEST AFRICA.

By W. Versfeld, B.A., B.Sc.

The localities examined are the following:—

(1). A strip of country about 20 miles from the coast, stretching from Velloors Drift and Ramans Drift on the Orange River to Keetmanshoop, via Warmbad and the Karas Mountains —a total length of nearly 200 miles.

(2). The coast belt from Luderitzbucht to Pomona, on which are situated some of the best known Diamond Fields.

(1). The first-named locality may be divided into two very distinct sections, namely (a) From the Orange River to the Karas Mountains to Keetmanshoop. Here the prevailing rocks are granite and gneiss, overlaid in the northern parts by Table Mountain sandstone and Dwyka conglomerate. (b) From the Karas Mountains to Keetmanshoop. Here the prevailing rocks are Malmsbury Schists, overlaid to a great extent in the southern part by Table Mountain sandstone and having enormous intrusions of dolerite in the northern part.

The Great Karas Mountains form the zone of contact of the Granite and the Malmesbury Schists.

It will be observed that I have adopted the names of the corresponding series in the Cape Province. The beds corresponding to the Cape series I have called Table Mountain Sandstone and to the Archæan Schists, Malmesbury Schists, though for the latter I would suggest a local name of "Karas Series" on account of their enormous development in the Great Karas Mountains.

A glance at the accompanying plan and sections will shew the distribution in greater detail. The geological sections do not represent a straight line but shew the formations passed over in travelling over the following route: Velloors Drift (on the Orange River), Velloor, Warmbad, Dreihoek, Kanghus, Waterfall (South West portion of the Great Karas Mountains), Quickachis, Harige Kaakebeen and Keetmanshoop. An additional section is shown from Dreihoek to Quickachis via Groendoorn (at the South East of the Little Karas Mountains).

Most of the above-named places have other native names, which are generally unpronounceable by Europeans.

The country between Orange River and Dreihoek—a distance of about 80 miles—may be described as an enormous mass of Granite and Gneiss, shewing here and there traces of the original Schists into which the Granite was intruded and only in the neighbourhood of Dreihoek being overlaid by younger sedimentary rocks, namely Dwyka Conglomerate. At several spots intrusions of basic volcanic rocks are observed.

The Granite and Gneiss vary enormously in their nature and appearance. One often merges gradually into the other, but in many places there is evidence that eruptions have taken place at

different times. This is well shewn in the neighbourhood of Warmbad. Here every possible variety of the two rocks is met with, of varying colours, coarseness of grain and proportions of constituent minerals. Coarse-grained granite appears in lenticular veins in Gneiss and in fine-grained granite. Sometimes all the constituent minerals are equally developed, at others the rock is distinctly porphyritic and often the Mica is entirely wanting. In places segregation or fractional crystallization of the constituent minerals has taken place to a considerable extent.

North-West of Warmbad is a good deal of very coarse-grained rock, generally consisting of Graphic Granite with large masses of Quartz often containing large crystals of Mica (Muscovite). The Graphic Granite consists mostly of Felspar with incompletely developed crystals of Quartz. In the largest segregations of Quartz are also crystals of Felspar. This Quartz occasionally sticks out like veritable reefs, except that the outline is very irregular.

Where the structure is Gneissose the several minerals often form distinct bands which give the rock the appearance of a stratified deposit. Such apparent anomalies as beds of Felspar and beds of Mica are observed in certain localities. At one spot I noticed a band of Biotite Mica about two feet thick formed of an agglomeration of crystals about one inch in diameter.

Garnets are very plentiful all over the granite country.

At Warmbad and other localities is a very large amount of beautifully coloured Granite and Gneiss, of which the Felspar is bright pink. The rock, in addition, contains a very large proportion of bright green Epidote (variety Pistacite) and varies greatly in grain and degree of lamination. It forms a most beautiful ornamental stone. A somewhat similar occurrence is seen at Ramans Drift (on the Orange River). Here the Schist (practically a Gneiss) which was evidently formed from an original sedimentary rock, contains a considerable amount of Epidote in fine layers filling cracks in the original bedding planes. Cracks in other directions also contain well crystallized Epidote. The Schist has been upheaved by Granite, of which several veins penetrate the former near the line of contact. A vein of Felsite is also noticed—probably from the same Granite mass. The surface of the Granite has copper stains at several places.

At many localities between the Orange River and Keetmanshoop one comes across traces of the original Archæan beds—Clayslates, Quartzites and Mica-Schists,—into which the Granite has been intruded, particularly where Gneiss is found. At Velloor a considerable amount of Quartzite and Mica-Schist was observed.

Intrusions of younger volcanic rocks are frequently met with. Between Velloor and Velloors Drift several narrow dikes of Diorite occur, generally running North East and South West. At Velloor a great mass of Diorite has been intruded. This rock is almost identical with the Copper-bearing Diorite of the O'okiep Mine in Little Namaqualand except that the latter appears to have slightly more free Quartz.

Some Diorite intrusions are also met with North of Warmbad.

At intervals there are also intrusions of Dolerite, which often stand out above the surface of the Granite and Gneiss.

A very large number of Quartz reefs are met with in the Granite, particularly just North of the Orange River, in the neighbourhood of Warmbad, near Dreihoek and further North. All round Warmbad are a large number of reefs of compact white Quartz. Some are of enormous size and form large white hills running for considerable distances. The apex of these hills is seen to consist of the Quartz reef in place, while the sides are composed of fragments of Quartz (including great blocks) that have been broken down from the reef. These reefs are particularly free from metallic contents, though a number of smaller ones near Warmbad and elsewhere contain a little copper in the form of Copper Pyrites, which is mixed with a considerable proportion of Iron Pyrites. A little Galena is also noticed. Traces of Zinc were found near Velloor.

Just South of Dreihoek the first occurrences of younger sedimentary rocks are met with, namely a few small outliers of Dwyka Conglomerate resting directly on the Granite. As far South as Warmbad some Sandstone debris is observed—apparently the remains of Table Mountain Sandstone that has been denuded. At Dreihoek a considerable bed of Dwyka Conglomerate occurs, resting at its southern end on granite, and at the northern end on Table Mountain Sandstone. This Conglomerate is well exposed, forming the cliffs on a river bank. It exhibits spheroidal weathering, and in places where the fine material preponderates, decided cleavage planes have been developed.

From here northward are a number of outliers of Table Mountain Sandstone and about twenty miles north of Dreihoek more Dwyka Conglomerate is found resting partly on Granite and partly on the Sandstone. From this point to Kanghus similar outliers of the Sandstone are seen at frequent intervals.

It is evident from the extensive distribution of the remnants of Archæan rocks and the enormous extent of country over which Table Mountain Sandstone is scattered in disconnected patches, that a great amount of denudation has taken place previous to the deposition of the Dwyka Conglomerate, and it is probable that the other members of the Cape Series, namely the Bokkeveld Beds and Witteberg Quartzites, may at one time have been extensively represented. I have, however, no evidence of their existence.

At Kanghus a considerable amount of Archæan Clayslate has been preserved, being overlaid by Table Mountain Sandstone, which in turn has a considerable amount of Dwyka Conglomerate resting on it. Further north the Dwyka appears to be wanting for a considerable distance, and right up to the Karas Mountains I have observed only numerous outliers of the same Sandstone resting on Granite.

At the Great Karas Mountains the formation becomes more interesting. The Southern hills are cappings of sandstone on great upheavals of Granite, while the Northern hills consist of enormous masses of typical Mica Schists, Quartzites, Clayslates and Limestones that have been upheaved by the Granite into a nearly

vertical position. As we proceed North the dip of these Archæan beds diminishes as does the elevation of the surface.

Soon we get to the Dwyka again, resting partly on Clayslates and partly on Table Mountain Sandstone which appears again. Just West of the Great Karas Mountains is an extensive deposit of Dwyka Conglomerate forming a low level plateau and extending towards the Little Karas Mountains.

A vast extent of Sandstone is now passed over, extending to a point about twenty miles south of Keetmanshoop. An interesting Dolerite intrusion is noticed in the middle of this extent of Sandstone. A small boss of Dolerite is surrounded by a thin fringe of Granite, which is in turn surrounded bv Clayslate, shewing that the Dolerite has carried up both rocks in the order in which they exist below the surface.

The Sandstone has at several localities, notably at a place boasting the euphonious name of "Harige Kaakebeen." a number of clayey nodules. Long before I visited this locality I was told about some wonderful camel tracks to be seen crossing a river. These tracks were described as being imprints in solid rock and, when I arrived at the locality and ascertained the geological horizon to which the rocks belonged, I was naturally anxious to find out what sort of camels had existed in Silurian or Devonian times. The supposed tracks were found to be cavities caused by the eroding action of water running over a hard rock containing soft nodules. Strangely enough the "Tracks" pointed across the river, but, on making investigations, it was ascertained that the river had fairly recently changed its course and had previously run at right angles to its present direction.

At a point twenty miles south of Keetmanshoop, the Sandstone disappears and the same Clayslates, Limestones and Quartzites that were observed at the Karas Mountains appear again, this time dipping to the South and apparently forming a vast Syncline over thirty miles wide. Mica Schist is not well developed at the northern end of the Syncline, having apparently been formed only where the original slates came in actual contact with the intruding granite.

From this point right up to Keetmanshoop these Archæan beds are met with at frequent intervals, the numerous breaks being due to very extensive intrusions of Dolerite, which has in all probability formed Lava flows, since there are outcrops miles in width. A borehole put down a few miles south of Keetmanshoop shews dolerite underlying the Archæan slates.

All round Keetmanshoop similar conditions prevail.

The Little Karas Mountains are composed mainly of rather flat hills of Table Mountain Sandstone. A great deal of erosion has taken place. Here are extensive intrusions of Diorite, in places shewing the same Archæan slates, Quartzites and Limestones round the bosses. Half way between Groendoorn, a farm in the Little Karas Mountains, and Quickachis is a great boss of Amygdaloidal Diabase, which has carried up a little Granite during the intrusion.

At numerous localities throughout the whole area described, a

recent deposit of Calcareous Tufa is observed lying on the surface rock. It consists of varied fragments of all degrees of coarseness, cemented together with Carbonate of Lime. This latter is most probably derived from the Archæan Limestones which have been denuded, and from the decomposition of the Lime Felspars of the basic-intrusive rocks.

With the exception of this land deposit, I have seen nothing more recent than the Glacial Conglomerate, from which I have come to the conclusion that this part of the country has been a land surface since about carboniferous times.

At Warmbad there is a hot spring from which the place derives its name. Water of fairly high temperature (about as hot as the hand can bear it) flows in considerable quantity from apertures in the granite. It is not used as drinking water, as it contains 130 grains of soluble salts per gallon—mostly chlorides and sulphates of soda and magnesia. Potash is also contained in smaller quantity.

Attempts are made to use the water for irrigating garden plots, but with poor success. Whenever the ground is allowed to dry a white efflorescence is observed on the surface.

A considerable quantity of gas is also ejected from the spring. Some of this was collected and roughly tested. It possessed the properties of Nitrogen, but there were no means of making any elaborate tests. Argon is a probable constituent of this gas.

(2) The coast belt from Luderitzbucht to Pomona.—A visit to this part of the world will reveal the first solid crust ever formed on this earth. The wonderfully tumbled mixture of Archæan rocks—Granite, Gneiss, Quartzites, and Mica Schists—points to one thing. The first cooling of the outer layers of molten matter forming our earth at that period of its evolution resulted in solidification and subsequent weathering of the solid portions of crust under conditions probably far more favourable to rapid decomposition of minerals than those which obtain at present. Sedimentary rocks were formed and then came a disturbance of equilibrium and the solid portions were engulfed in the molten matter forming the rest of the globe. This is exactly what one would expect to have happened several times before the crust finally became strong enough to resist any internal disturbances.

The whole coast belt, several miles wide, is a portion of a vast Titanic pudding, whose ingredients have been well stirred.

Journeying south from Luderitzbucht, one sees rapid alternations of Granite and Gneiss, shewing all degrees of lamination, Mica Schists with silvery cleavages and very compact Quartzites.

In the neighbourhood of Luderitzbucht the Granite and Gneiss preponderate while near Pomona the Quartzites become more numerous.

The baking process to which the sedimentary rocks were subjected has resulted in the formation of variously coloured rocks, the colouring matter being mostly the oxides of iron. Even Quartz reefs in the sedimentary rocks have participated in the baking and have in parts become impregnated with oxides of iron, generally red Ferric Oxide. All gradations from a ferruginous

slate to a jasper are noticed.

Here we find extremes meeting—as far as geological formations are concerned. What a vast interval between the formation of these rocks—to my mind far older than the other Archæan rocks met with in other parts of South Africa—and the next formation met with! Lying directly on these old schists and granites is a recent—we may say present day—formation, comprising the debris of the lower rocks, of which little but the Quartz remains. Felspars have been decomposed into clay, most of which has been blown to the north, a little remaining to form small clay bands here and there. Much the same thing has happened to the Micas, but the white and coloured Quartz pebbles are met with in large quantities, shifting about with the incessant winds and helping to wear down the rock surface.

In addition to the Quartz pebbles which form part of the present day formation one finds debris of Amygdaloidal Diabase, namely Agates and Chalcedony, sundry fragments of the local rocks and, last but not least, Diamonds—the debris, one may say, from pipes of "Blue ground."

This mixture, forming the diamond bearing gravel, occurs in the valleys and depressions and in smaller quantities scattered on the higher ground. The valleys have been largely formed by the eroding action of wind-blown sand and gravel. The rocks have been scoured and scooped and pitted to a remarkable degree. Boulders that have been partly imbedded in gravel have had the unprotected portion worn right off.

A good deal of the gravel is at present being solidified into a coarse grit, the cementing material being Carbonate of Lime derived from Archæan Dolomites and Limestones of which innumerable fragments are found lying in the gravel. Owing to the infrequency of the rainfall any dissolved Carbonate is easily redeposited.

In places the solidification is not yet complete, and the rock can be broken by scraping it with one's foot. In other places the process is further advanced and a fairly hard rock has been produced, which is in turn being subjected to the degrading action of the moving gravel.

As the original gravel contained diamonds, the solidified mass does too, and this has given rise to a statement that the original matrix of the diamond had been discovered.

This solidified gravel has, I find, been described as being of Cretaceous age. This statement I could only accept if indisputable evidence is brought that the deposit contains fossils which are found in Cretaceous beds and not in more recent formations. The fossils that I have observed are all present day sea shells, and the reason for their being in their present position is a very simple one.

I had heard so much about the gravel being of marine origin, as evidenced by the marine shells observed miles inland, that I naturally looked closely into the matter. True enough at many places shells were found scattered amongst the gravel. These were mostly the shells of mussels and limpets—to give them their

popular name. On following them up to windward, namely south, they generally increased in number until a large mass was encountered. In several instances I noticed the remains of Hottentot habitations at these accumulations of shells. In one case a little excavating revealed the remains of a fire-place and a piece of clay pot.

In this desert country, with hardly any vegetation, what is more natural than that the original inhabitants should go to the sea shore for their food supply?

Several burying places of Hottentots are seen near the coast.

The decisions finally arrived at are that the solidified gravel is derived from the loose gravel and not vice versa; that the Diamond-bearing gravel is a recent deposit (that is, geologically recent) and that it is not of marine origin. What then is its origin? Let us examine the facts as we find them: Here we have a land surface, which, in the absence of evidence of submergence, we can assume to have been a land surface from the earliest Archæan times to the present day—a lapse of time which we are utterly unable to realise and which may practically be described as an eternity. Somewhere near the Carboniferous or Permian Periods—a few million years either way are of no account—an enormous number of pipes of Diamond-bearing "blue ground" were formed, the actual rock being brought up to the surface and most probably considerably overflowing it. In the natural course of events denudation proceeded to an enormous extent and the decomposed "blue ground" was scattered far and wide.

When we consider that a large number of diamond pipes have been discovered more or less by accident, and that our prospecting and mining operations affect an infinitesimal proportion of the earth's surface, it would be absurd to assume that there are not a vast number of diamond pipes still undiscovered. The debris from these pipes, formed during the denudation of the surface to its present level, will of course form a very small proportion of the debris formed from all the other rocks that have been degraded, *except where the conditions for concentration are favourable.* Concentration can be effected in the following ways:—

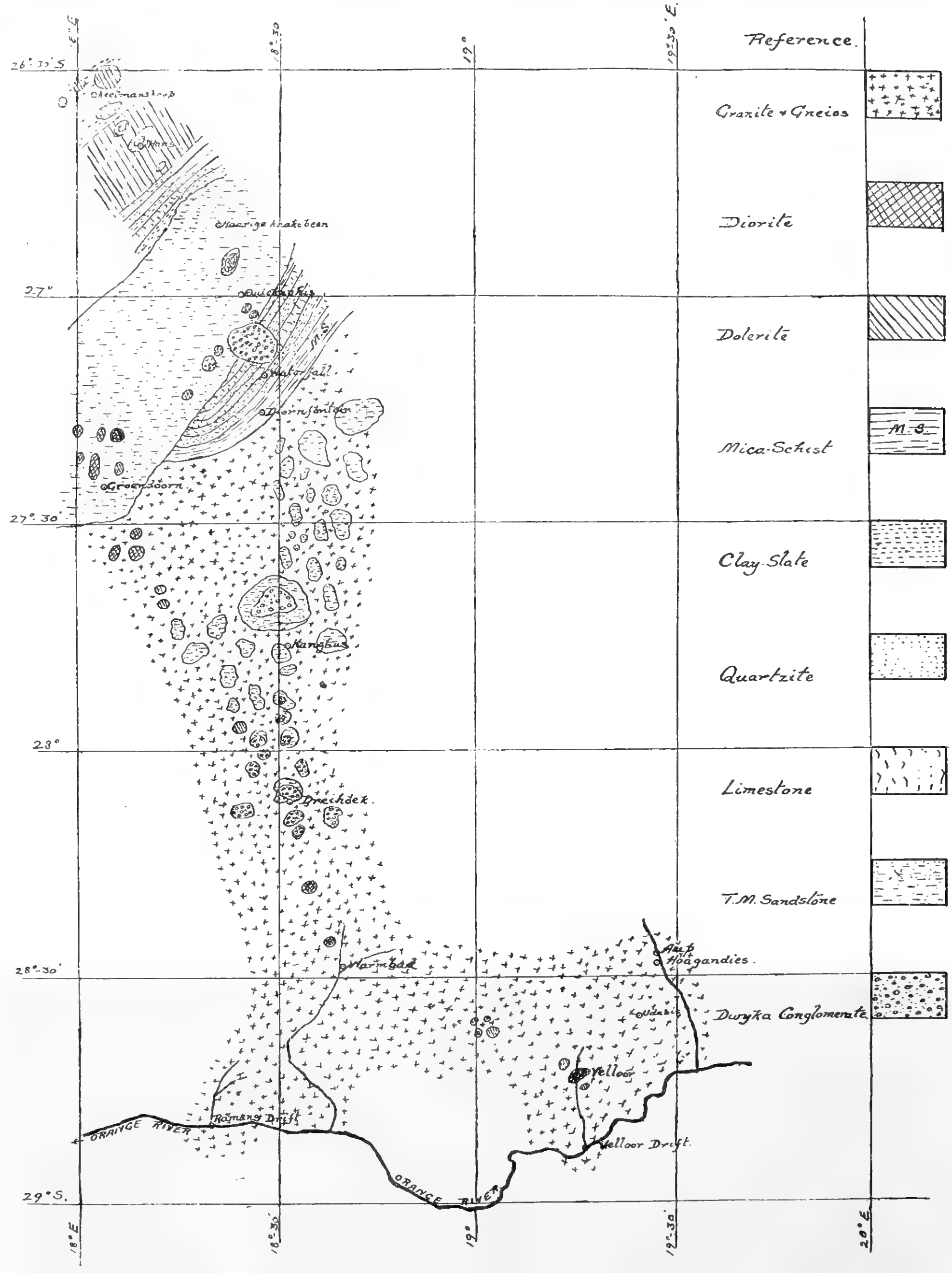
(1). By means of moving water.

In this way deposits of diamond-bearing gravel have been formed on the banks and in the beds of rivers, and many such are at present being worked. Owing to the mechanical action of the water being very irregular, as it depends on the rainfall, this method of concentration is not ideal and these deposits are naturally irregular in their occurrence and richness.

(2) By means of wind.

It would be difficult to imagine more favourable conditions for wind concentration than exist on the coast belt of German South-West Africa. A very small rainfall, the prevalence of furious and well nigh incessant trade winds, and the presence of a rock surface which is rather resistant to the chemical action of air and moisture, have resulted in the concentration of coarser particles of debris in the depressions in the rock surface and the removal of the fine material which has been blown towards the equator.

Geological Plan of Portion of German South-West Africa.



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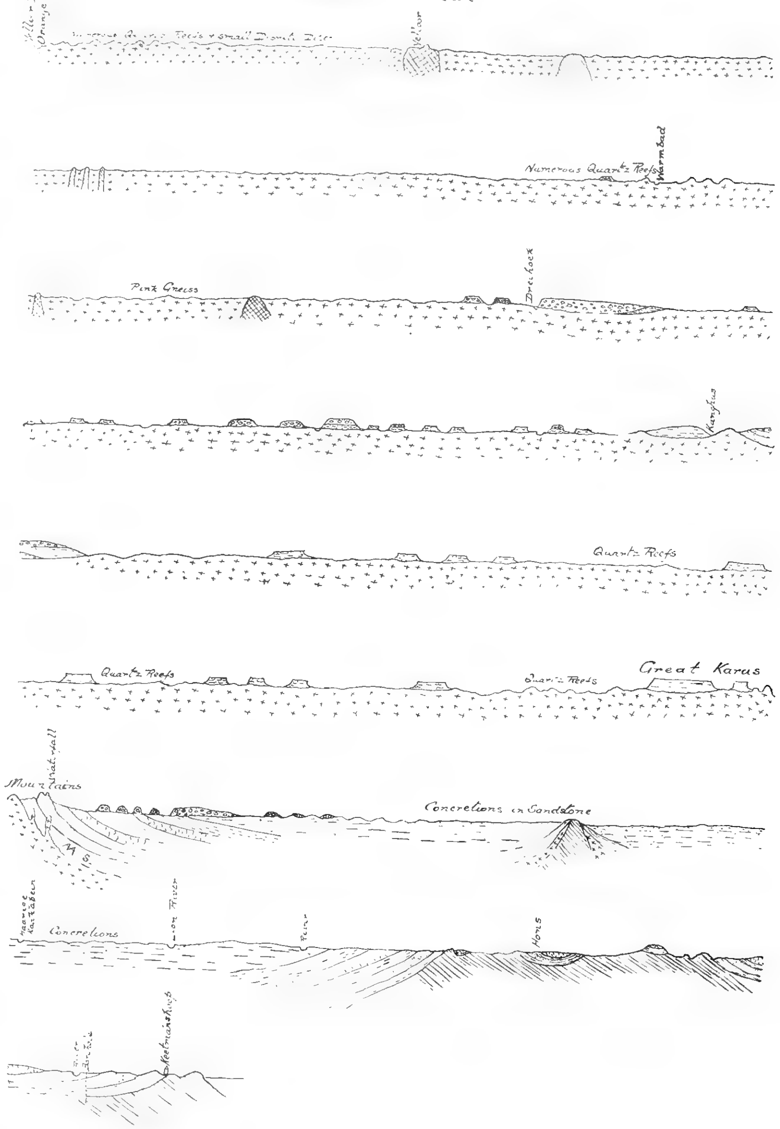
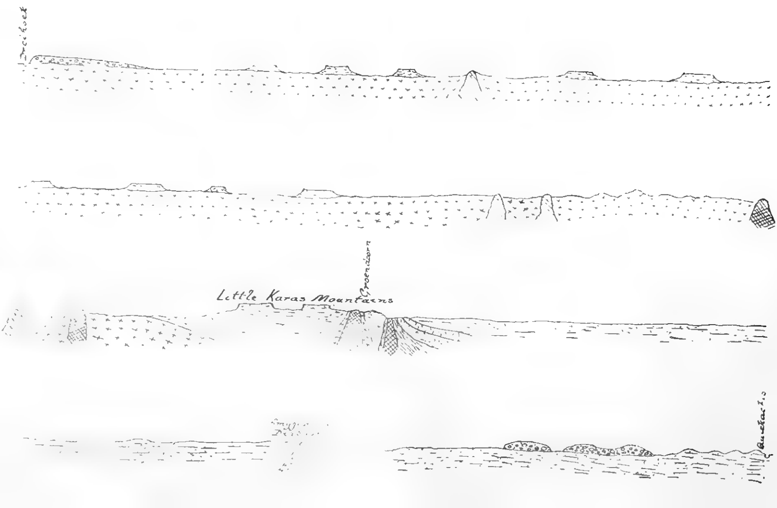


Section from Dreehoek to Queckaches via Little Karas Mountains



Of these coarser particles further concentration takes place on account of the difference in weight of similar sized particles of different minerals. The mixed debris which has gradually found its way to this locality, contained also diamonds from the nearest pipes and the gravel which now remains is naturally far richer in diamonds, this mineral being about 35 per cent. heavier than most of the other particles with which it has been associated.

This seems to be a simple and natural explanation of the presence of the diamonds, though several different theories have been advanced.

It would be idle to speculate on the probable position of the pipes from which the diamonds were derived, for the simple reason that it is very unlikely that the various agencies that have influenced the removal and concentration of loose material, were always the same as we now observe them. For instance, one can readily understand that if at any period of the earth's history the great extent of inland country to the east and south-east of Luderitzbucht were not covered with soil, but resembled the coastal belt, diamonds may have been transported for many hundreds of miles in the same way as they are at present being shifted in the neighbourhood of Luderitzbucht.

Again, if at any time the axis of the earth had occupied any other position than its present one, the direction of the trade winds would have been different and the wind transportation would have taken place in quite a different direction.

In conclusion, I would emphasise the futility of laying down hard and fast theories founded on the observation of the present day condition of the earth's crust.

In geological history time and space are practically illimitable.

Our knowledge of the Earth's crust is indeed very limited. We live on the surface and here or there we dig or scratch and draw pipes, it seems a safe conclusion to come to that the number still conclusions from what is revealed to us. A very large proportion of the rocks forming the crust is covered with soil, and we remain in profound ignorance of what is beneath.

But since our more or less random diggings and scratchings have revealed the existence of a large number of diamond-bearing pipes, it seems a safe conclusion to come to that the number still undiscovered must be very large indeed. The discovery of some, much nearer to the Luderitzbucht deposits than those at present known seems well within the bounds of probability.

MAIZE INDUSTRIES.—In a recent issue of the *Chemiker Zeitung*, an account is given of Doby's investigations into the possible productiveness of maize as a source of sugar, cellulose, and alcohol. In Germany, although the culture of maize proves profitable, the proportion of sugar is lower than in America. The amount of sugar may be increased by removing the young cob before the seeds ripen. For the manufacture of paper the stems, leaves, and axis of the cob are of value, the unripe cobs and the green stems being capable of yielding alcohol.

THE CONQUEST OF THE AIR.

By Prof. H. Bohle, M.I.E.E., M.V.D.E.

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I have divided the subject into three parts. In the first part I give a general account of the progress made in aviation since the year 1782. The second part deals with balloons and airships, the last with aëroplanes.

Just a few years before 1782 the waves of the French revolution dashed against the throne of the Bourbons. The time of great inventions had commenced. Some insight had also been obtained into the laws of atmospheric pressure, although Frederick the Great refused to be convinced of them, and a scientist who lectured before him on the subject was taken to the theatre where, pointing out the pretty dancer Barberini, the king said:—"Do you, ass, still believe that 200 ctrw. presses on a human being?"

At Annonay in France, there lived at this time two intelligent papermakers:—Jacques Etienne and Joseph Michael Montgolfier. "Air heated," said Etienne one day to his brother, "is lighter than cold air. If then we take a cylinder, closed at the top and heat the air in it, the cylinder must rise." "Certainly not," said Joseph, "unless you make the cylinder exceedingly light." Etienne tried his luck with paper, but it was found to be too fragile. But finally the brothers managed to build a large sphere of linen, lined with paper, about 10 metres in diameter with a contents of over 500 cubic metres. Even by driving out only about one quarter of the air, an upward pressure of about 125 kgs. could be obtained, and as long as the balloon weighed less, it would have to rise. The lower end of the balloon was open, the opening being formed by a wicker ring one metre in diameter.

It is the 5th of June, 1783. The balloon hangs about one yard above ground between two masts. The willow ring carries, by means of six iron wires, a metre below, a pan with a charcoal fire. Slowly the balloon expands. Before long the pan is raised from the ground. The ropes holding the balloon are placed under tension. A pull, and majestically, for the first time, there rises into space a product of human intelligence.

The success at Annonay made the scientists at Paris jealous, and something had to be done by one of them. The one who succeeded was Charles. Said he, "If a sphere filled with hot air will rise, how much more if hydrogen gas is used"? No sooner said than done. On August 27th, 1783, he set free a number of balloons 4 metres in diameter, but this time filled with hydrogen. One half of the Paris population was present. Thus followed on the Montgolfière, the Charlière.

But the brothers Montgolfier were not idle. On September 19th of the same year they sent up a balloon in the presence of the

King and Queen. This procured them an invitation from the Academy of Science, and to honour the occasion they made up their minds to do something great, *viz.*, to build a balloon which would carry a person. They constructed a specimen painted in all the colours of the rainbow, 26 metres high, 15 in diameter, ending in a narrower part of 5 metres diameter with a wooden gallery, on which a person could move. The question arose, who was to travel in it. Finally the King ordered that the journey was to be made by a criminal condemned to death, who should be pardoned if he came safely to earth again. Everything had been arranged when Pilâtre de Rozier declared that it would be a disgrace to mankind if a murderer were the first person who ever travelled in a balloon, and he offered himself. It was a great disappointment to the criminal; but for humanity it was more dignified. The ascent took place on November 21st, with Pilâtre de Rozier and the Marquis d' Arlandes on board. The landing was also safely accomplished; but the balloon was destroyed by superstitious farmers. On this followed again a Charlière with Charles and Robert on board, on December 1st, 1783.

It is the year 1870. We are again at Paris. The air is full of strange noises and the roar of cannons. Shrapnels draw their fiery courses across the horizon. Paris, the centre of culture and civilisation, lies within the iron grip of the German army. Food, coal, and wood have almost disappeared. The streets are in the deepest darkness. The gas works have ceased to work for want of fuel. Only at one of them a few lamps light up a large yard. Solid and black rises the huge gas tank. In the middle of the yard appears a large yellow sphere, growing larger and larger. A roaring noise indicates that gas is forced with considerable pressure into the balloon. A net is being spread over the yellow sphere and men are busily hooking sand bags into the lower meshes. The inflating is now complete. A cage is fixed to the net. Provisions, clothing, and furs are placed inside. Men pass the lines of the Mobilgardes without trouble with post bags from the Parisienne Government to the Government of the National Defence. Two persons enter the balloon, and it is high time, for the men can no longer hold the balloon, which, under the rushing of a violent wind, moves backwards and forwards like a wounded monster.

Attention, en avant! With lightning-like speed the balloon rises into the darkness. What will be its fate? The bold aeronauts are no longer troubled by the gale, because they now float with it and to them everything is calm itself. A hissing and roaring noise of a passing shrapnel, however, tells them that they have not yet left the danger zone. Instinctively one of the aeronauts drops a sand bag. The balloon makes another leap although it is not noticed by the passengers. But a stolid Pomeranian Grenadier wonders no little that in France it rains sand in a clear sky. The night passes. Belgium must by now be reached. As the sun rises and the fog disappears the aeronauts notice 300 feet below them the stormy sea. They take the situation calmly, but at the same time they are careful of their sandbags. The short winter day comes and goes, the second night appears. Deeper and deeper

sinks the balloon. On putting his head out of the basket, an aeronaut is struck by the branches of a fir tree. The next instant the anchor drops. They have landed.

The morning comes and with it the people. The parson of the little village tells them that they are in the North of Norway. They had evaded the Germans, but the delivery of the mails was somewhat delayed.

Comparing the balloon with its predecessor of nearly 100 years earlier, it had grown but little. It was still the small and unreliable child, as Benjamin Franklin said, when he saw the ascent of the first Montgolfière in 1783.

Let us return once more to France in 1884. We are on the field of Chalais near Meudon, and see a large group of French officers and civilians in a lively conversation before a large shed.

"I tell you, Captain," says a civilian, "that you will have little pleasure with your electric battery. Imagine the terrible weight which you will have to carry." "I know that," answers the Captain, "but I am confident that in a few month's time we shall be able to store ten times the quantity of electricity without increasing the weight, and then the dirigible, electrically driven airship will be an accomplished fact." "Nothing of the sort. I will not deny that you will be able to have a little trip on a calm day like this, but what will happen if the wind blows at twenty miles an hour? In such a case the speed of your ship should be at least 30 miles an hour, and it is not."

"You are incorrigible, Doctor. With such a biting criticism James Watt would never have attempted the problem of the steam engine, nor Stephenson that of the locomotive. Without optimism and hope nothing is ever done. Perhaps after all, the names of Krebs and Renard will some day be known in the world."

A sign to a servant and the gates of the shed open. Soldiers bring out a huge cigar shaped balloon. Below is hanging a long lattice-like cage. Bright propellors shine in the sunlight. Two officers, Captain Renard and another, climb into the cage. Sand bags are taken away. The balloon rises two or three metres. A turn of the handle and in place of the sparkling propellors we see a glittering transparent disc. The motor is rotating. *En avant!* Gracefully the cigar rises and describes a loop over the field. On the latter stands the Doctor, stopwatch in hand and looking through a telescope. The time in which the ship appears and disappears is nine seconds. As the balloon is 50 metres long, the speed is about 5 metres per second or about 12 miles an hour. Too slow, is the Doctor's comment. The ship moves in the direction of the Villa-Coublay. Twenty minutes have passed; the ship is well on its return journey. Twenty-three minutes. The ship has arrived at its starting place. For the first time in history has a dirigible balloon made a journey and come back to its starting place.

But the battery was completely exhausted. The inventors saw that the electric propulsion was not a success. Only 23 minutes did the current last. In the rejoicings which followed, the inventors remained exceptionally quiet and out of humour.

In 1904 we find ourselves once more in France. The French automobile industry is gaining enormous successes. The Gordon-Bennett cup has been won. The world has seen that France possesses the best and fastest motor cars. The motors are light and strong. Only 3½ kgs. to the horse-power. A fifty H.P. motor weighs only 175 kgs. Where material was not wanted it was drilled away. What a reduction in weight when compared with the battery and electric propulsion used twenty years ago by Krebs and Renard. A gentleman of the South, evidently from Spain or Brazil, passes over the square at Meudon. We see him enter a large shed. The sliding doors open and a yellow cigar shaped balloon becomes visible. A buzzing noise indicates that a motor is working. A number of men pull the cigar out of the shed. The person from Brazil steps into the cage or gondola hanging below the balloon. Now the nose of the ship rises into the air. A jerk of the hand and the coupling joins the motor to the propellor shaft. Like an obedient horse the ship leaves the yard, rises to a height of 200 metres and takes its course.

The man in the gondola was Santos Dumont, the young millionaire, who spent his money for the advancement of technics. Santos Dumont possesses a charmed life. With a pluck and determination, which one cannot too much admire, he builds one ship after another, to come to grief time after time, only to rise and try afresh. He may not have advanced the science of building dirigibles to a great extent; but he has certainly stirred up interest in ballooning and tried what is essential for dirigibles, motors of high horse-power and small weight.

In the Bois de Boulogne people are out for a walk. Pigeons are flying over the heads of the gay. "If I could only fly like that" is the ardent thought of an aristocrat as he has difficulty in keeping his full-blooded horse under control.

"Bon jour, Monsieur le Comte, are you enjoying your ride? If I were not an aeronaut I should also go in for this pastime." "I congratulate you, Monsieur Dumont. It is delightful for me, although not for my horse, to be accompanied in this matter. I just envied the birds; but now I envy you still more."

"Well, I invite you for a trip on Sunday next, M. le Comte, you need not come to Meudon, I shall pick you up here. Your weight is 75 kgs. so I shall bring a sandbag of similar weight." The Count then forces his unruly horse towards the balloon. Dumont drops another yard or two. Both gentlemen shake hands and separate.

The papers are full of reports of this journey. Captain Renard, who has advanced to a Colonelship, shakes his head and murmurs: "The motor, the motor! If I could only have had a motor like that twenty years ago!"

We find ourselves next in Germany. A cavalry General of the ancient family of the Zeppelins has just retired from the army. He was the first officer who in 1870 as a scout entered France, where he did noble work for his country. The success of the French balloonists during the war made him ponder about a dirigible balloon. When his retirement came, the old General,

instead of enjoying a well-earned rest, set to work to build airships. The able soldier, used to discipline, knew that he would have to become an engineer first. Count Zeppelin took no steps of which he was not convinced that they were logically and scientifically correct. Time after time he asked the leading men of one of the greatest engineering societies the world knows—the Verein Deutscher Ingenieure; "Tell me, gentlemen, where I err, where I go against scientific laws, where my investigations want extending." This conscientious training and experimenting stood Zeppelin in good stead when accident after accident befell the aged Count. "I will build a ship which is as much at home in the air as a ship is on sea," were his remarks. "Not a balloon, I want, I will have a proper ship."

Near Manzell on the Lake of Constance, there rises a huge hall. Since 1899 Zeppelin has been experimenting on a rigid dirigible, spent all the money he possessed, gained successes, came to grief, built afresh. Two days of accidents destroyed the work of years.

Five years were required before the Count had collected sufficient money to enable him to build his second ship. Then arose the magnificent and huge Z2, and in the first Winter days of 1906 Zeppelin commenced his journeys. A sudden and strong wind drove the ship from the lake and landed it on a frozen field. (The steering planes were not large enough.) The following night of gales made a complete wreck of this ship. But Zeppelin, now 68 years of age, did not despair, and nobly was he supported by wife and daughter. They sold even their jewels and gave up their comforts to enable their hero to build a third ship. With the perseverance of a Manichee, and the briskness of a boy, he secured the remainder of the money he required. Already in the Spring of the same year Z3 was commenced and finished in October. We all know the success of this ship. The world was astonished when it read of the Count's successful trips, on which the ship attained train speed. The nation now took the matter in hand and Zeppelin was asked to build a ship for the Government. Z4 was commenced in the Spring of 1908. The world was electrified, when it heard of the brilliant trip into Switzerland, lasting 12 hours, the greatest journey made by a dirigible. Then came the epoch-making journey from Friedrichshafen to Mainz and back. Once more the elements made havoc of the ship after it had made an effective landing on *terra firma* at Echterdingen. A squall bumped the ship against the ground, electrical discharges set the gas on fire, and within a few minutes the magnificent ship was a complete wreck. This heavy misfortune, however, roused the patriotism of Germany in a manner that may serve as an object-lesson to other Nations. Within a few weeks a sum of £300,000 was collected and placed unreservedly in the hands of the national hero. Town Councils subscribed money from the Municipal funds, children gave their mites, rich and poor opened their purses. Manufacturers provided the aluminium and coverings free of charge. Where formerly a lonely man made his experiments with a few enthusiastic admirers, there now stand large factories built with the money of an admiring nation, a free

gift of the people, who at last grasped the outcome of heroic and noble work. Accidents will always happen whenever we deal with locomotion of any sort. Personally I feel convinced that the airship invented by Zeppelin will be the ship of the future. Mishaps must be expected to occur while the lessons of aeronautics are being learnt. Count Zeppelin has the satisfaction that in all his accidents, not a single person has been killed. When once the country possesses landing halls all over, the danger of having accidents will practically disappear. The landing is not the most dangerous part in the conducting of the huge Zeppelin airship. Nearly all the accidents have occurred after the landing. For nearly forty hours at a time have Zeppelin ships been in air, journeying over 600 miles, more than any other tye of dirigible so far invented.

Having given a general outline of the progress in balloon aeronautics, I intend now to deal with the balloon and airship somewhat in particular, *i.e.* with the second part of my lecture. I commence with the ordinary balloon. Balloons will never be out of date. A person who intends to become the conductor of a dirigible must first thoroughly understand a free balloon.

The material used for the covering is a cotton fabric covered on the inside with rubber so as to prevent the leakage of the gas and resist the damp. Varnished cloth and gold beaters skin are also employed.

The covering is usually made in layers. Beginning with the outside:—A layer of cotton cloth impregnated with a yellow chromate of lead to keep out the blue to ultra violet rays which do damage to rubber; two layers of vulcanised rubber to retain the gas; three layers of cotton to reinforce that on the outside; four thin layers of rubber to protect the cotton against the chemical action of the hydrogen.

By means of templates the cloth is cut into strips or gores, which are sewn together to form a sphere. The poles of the latter are provided with openings, the upper one for the valve with which gas might be let out at will, the lower opening is joined to the hose for filling the balloon. Strong springs prevent an accidental opening of the valve. When the balloon is inflated the lower opening ending in a short hose is temporarily closed. It must, however, be opened before the balloon rises, in order to prevent a bursting when sun rays heat and expand the gas or the expansion is due to thinner air in high regions.

Besides these openings, the balloon is provided with a third one, which, however, is closed with the so-called ripping gore. The latter, which is not sewn but stuck on, is pulled off shortly before the balloon reaches the ground in order to empty it quickly and prevent the balloon from bouncing about. The ropes which control the valve and the ripping gore pass through the inside of the balloon on a net placed over the envelope. The basket carries from two to five persons according to the size of the balloon, along with instruments such as thermometers, barographs, pocket barometers, aspiration psychrometer for temperature measurements, hygrometers for measurement of dampness, the usual outing instruments, such as camera, maps, provisions and ballast.

For inflating we employ in most cases ordinary gas from the gas works. If therefore in this country we wish to go in for ballooning, we shall have to extend our gas works. Gas may, of course, be bottled and transported in steel bottles, but this is rather expensive. Usually this is done by the military. Such bottles may also take the place of the ballast. The latter consists as a rule of sand, in bags of 15 to 20 kgs. weight. The ballast is of immense importance to an aeronaut and gives him a certain freedom in his actions. Once all ballast has been dropped the control has gone. For landing, at least two bags should be kept in reserve, in order to prevent heavy impacts on the ground. At the last moment, the bags are emptied. The upward pressure of a cubic metre of ordinary gas is about 0.7 kg., hence a balloon with a contents of 1,000 cubic metres has an upward pressure of 700 kgs. Its weight is about 250 kgs., so that 450 kgs. are left for ballast, equipment and passengers. With such a balloon the ballast should weigh not less than 10 sand bags of 15 kgs. each, so that 300 kgs. are left for provisions, outfit and two passengers.

During recent years the ordinary gas has often been replaced by hydrogen, which gives an upward pressure of about 1 kg. per cubic metre. This is of great importance. It means that a balloon with 1,000 cubic metres content has an upward pressure of 1,000 kgs., so that after deducting its own weight of 250 kgs., 750 kgs. are left for ballast, equipment and passengers.

When an ascent has to be made, the envelope is first spread out, the net carrying the basket is then placed over it, the hose from the gas mains is joined on, and gradually the balloon becomes inflated. As the sphere becomes larger, sandbags are hooked into lower meshes of the net. In the meantime the basket is made ready. When the inflating is accomplished, the hose is disconnected, and until the ascent commences the lower end of the balloon is closed. The cage or basket is now joined to the sphere and the conductor enters with his companions. The weighing now commences. This is done by an expert and consists in the determination of the number of sandbags to be carried. Ready hands lift up sandbags and cage, others take bags away until the expert thinks that the upward pressure is just right. The lower end of the balloon is then opened again and the ascent begins.

The landing is carried out as follows :—When the ballast is running short or other reasons make a landing necessary, the aeronaut looks out for a suitable landing place, if possible near a railway station or in a field where little damage can be done to the crops. When such a spot is found, the conductor pulls the valve line, which opens the valve at the top of the balloon and allows the gas to escape. His companions keep the sandbags ready, employing them if the descent is too rapid. Just before the balloon reaches the ground the ripping gore is pulled off which empties the balloon almost instantaneously. The balloon is then packed together on a wagon and taken to the station.

Ascents of this nature are on the whole connected with little or no danger. As a matter of fact, in spite of the accidents we have

read of lately, ballooning is less dangerous than motor car racing or American baseball. And what a magnificent sport it is! Not to think of the valuable research into the laws of the atmosphere which has been carried out in the baskets of these balloons. The magnificent panorama which is offered to the eye of the aeronaut! God's world lies at his feet and even in the wildest storm he does not feel the wind, because he floats with it. And a careful aeronaut, who knows his work, will be able to land safely in a gale. The greatest height to which a balloon has risen with passengers on board is 11,000 metres. Oxygen had, of course, to be inhaled by the aeronauts.

Before I leave the balloon and pass to the airship I should just like to say a few words about the endeavours which have been made to reach the North Pole by a non-dirigible. The bold aeronauts who attempted this were Fränkel, Andree and Kandidat Strindsberg. For this purpose Andree intended to build a balloon which should fulfil the following conditions :—

(1). The upward pressure should be sufficient to enable the balloon to carry a large quantity of provisions, ballast and three passengers.

(2). The balloon should not lose gas at a more rapid rate than amounting to a loss of upward pressure of 45 kgs. per day.

(3). It should be somewhat dirigible by the employment of sails and towing or guide ropes. This he had tried with balloons flying across the Baltic Sea, when he found that he could steer 27 deg. out of the direction of the wind.

The balloon, to do this, should have a carrying capacity of 3,000 kgs., with a contents of 6,000 cubic metres. Andree voiced his intention in the right quarters and soon had together the 128,000 crowns necessary for the purpose. Unfortunately, he reduced his balloon to 4,500 cubic metres, and the meteorologist, Ekholm, who had intended to accompany Andree, refused on this ground to do so, and Fränkel took his place. It was also found that the loss of upward pressure per day was nearly 100 kgs. instead of 45. The sails which Andree used were a little over 80 square metres large, the guide ropes were 3 in number, the longest one was 400 metres long and weighed a ton. Andree intended to pull it over the ground for a length of 150 metres, so that the journey would take place about 250 metres above ground but below the clouds, as was essential. The cage was fixed in such a way that it could be detached with a single twist of a handle. It was not unlike a ship's cabin with a roof and a railing. Andree's friend, Göransen, invented also a harmless cooking stove, hanging 15 metres below the basket, which could be lighted and extinguished from the cage.

Unfortunately, directly after the ascent, two of the three guide ropes dropped. The balloon thereby lost 700 kgs. of ballast and rose to a height of 700 to 800 metres, when the third rope also became useless as a guide. Of the 13 floating buoys carried by the aeronauts, five were found, two having notices saying "All's well." Only one carrier-pigeon was caught by Captain Hansen

of the *Alken*. The notice was :—

"13 July, at 12.30 p.m., latitude 82 deg, 2', longitude 15 deg. 5' East. The voyage is rapid towards East 10 deg. South. All is well. This is the 3rd pigeon post. Andree."

Let us imagine the end of this fateful voyage. The loss of the two guide ropes and thus of 700 kgs. of ballast soon placed the aeronauts at the mercy of the elements. The loss of gas made the balloon sink more and more. The last guide rope and the sails became useless and had to be dropped in order to get into higher regions and more favourable air currents. Still, the balloon soon dropped again, the last of the ballast had to be sacrificed. Then followed the instruments, all unnecessary equipment, provisions, and yet the balloon dropped. Probably this happened near the peninsula Kola. As a last resource, perhaps when safety was almost in sight, the basket reached the icy sea. It had to be sacrificed and the aeronauts clung to the wooden ring of the balloon. Even this did not increase the upward pressure of the balloon sufficiently to carry it to the land, and the adventurers found a grave in the icy sea. On July 17th of the same year Captain Lehmann of the steamer *Dortrecht* saw to the North of Kola, a dark object in the sea, and birds flying to and from it. It was in latitude 69 deg. 38' and longitude 35 deg. 34'. Each gust of wind seemed to sway the floating island backwards and forwards. In all probability this was the ill-fated balloon. Unfortunately, when a mile away, and seeing that no human beings were on it, the Captain turned his vessel.

I shall now deal with airships. The shape of the airship should be such that the air resistance becomes a minimum. A sphere has a greater volume, proportionately to its surface, than a body of any other shape. To drive a sphere through the atmosphere requires half the power needed to propel a circular plane of equal diameter flatways on. The cigar-shaped form offers a good deal less resistance than this; but it has an envelope that is heavy relatively to the volume of gas imprisoned. Its efficiency may be augmented by a general increase in dimensions—the proportions being constant—as the doubling of surface area of the envelope far more than doubles the cubical contents.

Experiments have shown that a hemispherical prow and a conical tail give the best results as regards minimising air resistance. It is much less important to avoid a blunt prow than to keep the lines of the after-part fine, since the resistance of air to being pushed aside is small as compared with the "suck" of a badly-shaped stern.

Major G. O. Squier, of the U.S. Army Signal Corps, laid it down that the power consumed in propelling a displacement vessel supported by air or water at any constant speed is considered as being two-thirds consumed by skin-resistance and one-third by head-resistance; and that a dirigible balloon carrying the same weight, other things being equal, may be made to travel about twice as fast as a boat for the same power, or to travel at the same speed with the expenditure of about one-eighth of the power. As there are practically always currents in the air, reaching at times a velocity of 20 and 30 miles an hour, a dirigible

balloon should be able to travel at a speed of about 50 miles per hour. It will then be available under practically all conditions of the weather. In other words, it should have as much power as would drive a boat, carrying the same weight, 25 miles an hour or should have the same ratio of power to size as the *Lusitania*. In the construction of dirigibles the outstanding points are, therefore, small air resistance, by suitably shaping the balloon, large motive power at a small weight, excellent steering facilities, and stability.

As a matter of fact, dirigible balloons became a possibility with the advent of the benzine motor. It is now possible to obtain motors which weigh only 1½ to 2 kgs. per horse power. Even in the year 1900, the weight was still 20 to 25 kgs. per H.P., so that an enormous success in this direction has to be recorded.

The present-day dirigibles are divided into three classes: The non-rigid, semi-rigid, and rigid types. Perhaps the best way of studying them is by describing one of each class.

One of the most successful non-rigid airships is the one due to Major Parseval. It has the correct shape: An egg-like prow and a pointed tail. The envelope consists of gores 900 mms. wide, made in a similar manner as for the free balloons. The colour of the envelope is again yellow to prevent the passage of the oxidising rays, and the consequent deterioration of the rubber on the inside of the covering. The two layers of cotton cloth are laid diagonally to one another, so that the warp of the one may resist ripping in the woof of the other and localise injuries to the fabric. Just below the Equator of the ship is fixed a belt which carries the gondola, or car, and the propulsion mechanism. In order to keep the balloon always taut, two air bags or ballonets are placed inside the envelope. Air is constantly pumped into them, escaping through a valve if the pressure exceeds 20 kgs. to the square metre. As soon as the pressure on the inside of the covering exceeds 10 kgs. to the square metre, the balloon is able to carry the cage and its equipment. The covering is of such strength that a bursting will not take place until the pressure exceeds 450 kgs. to the square metre. Hence sufficient margin is left for safety. If the gas is expanded by a rise in temperature, the ballonets are squeezed until the pressure is normal again. On the other hand, if the gas contracts or leaks, the ballonets swell out until equilibrium is restored.

It will be obvious from this that the proper working and size of the ballonets is of vital importance to a non-rigid balloon. The amazing number of accidents which befel Santos Dumont were nearly all due to insufficient size of the ballonet and the small quantity of air that he could pump into it. The gas contracted more rapidly than the air could be pumped into the ballonets. A collapse was the inevitable result.

In addition to the air bags, the ship must be provided with safety valves. When the ballonets are almost squeezed flat, and the gas keeps on expanding, a safety valve, manipulated by means of ropes by the bags themselves, automatically opens and allows gas to escape. The valve may also be opened by hand.

The two ballonets in the Parseval airship serve also for mak-

ing the balloon ascend and descend. If the balloonist wishes to rise, air is pumped into the ballonet near the tail and squeezed out of the one near the prow. The latter becomes thereby lighter, the former, heavier, so that the balloon is placed under an angle, with its nose in the air. As the motion takes place in the direction of the axis, the ship must rise, especially as the wind now catches the underside of the ship. The reverse takes place when the ship is to descend or land. Air is then pumped into the ballonet near the prow and squeezed out of the one near the stern. On account of the somewhat sluggish action of filling and emptying the ballonets, Parseval added a 40 kg. weight running on ropes by means of rollers, which may be moved on either side of the centre of gravity.

In the 1910 type of sporting balloon, the ascending and descending is accomplished entirely by means of elevating planes placed under the prow. The lateral steering apparatus consists of a rudder having an area of 8 square-metres joined to a vertical stability plane of 20 square-metres. In order to prevent oscillation round the horizontal cross axis, and tilting, damping planes of 18 square-metres surface are employed near the tail. These consist of square-shaped fabrics fixed by ropes to steel tubes. The fabrics are arranged in a manner so as to form air cushions, by carrying in the middle a wind catcher. For rapidly emptying the balloon, 4 ripping gores are provided to each ship.

Very ingenious is the way in which the car or gondola of the Parseval ship is fixed. In order to prevent the ropes which carry the gondola from indenting the balloon, very long ropes have to be employed. This lowers the centre of gravity to a very great extent and thus increases the danger of tilting. Parseval prevents this by fixing his gondola moveably on ropes and rollers. Suppose the motor is set going. It then moves the cage forward and consequently pulls the ship along. As the latter receives the greater part of the wind pressure, it will tend to rise, and the result would be pitching. In the Parseval ship, as the gondola moves forward, it slides along the ropes and thereby moves the centre of gravity forward, which places the forward ropes under tension and keeps the nose of the ship horizontal.

Noteworthy also is the construction of the propellor blades. They are also non-rigid, and consist of cloth fixed to a steel chain weighted by cross steel bars. When the motor is not in action, the blades hang limply downwards. As the speed increases, the centrifugal force of the steel chain and rods stiffens the blades. Weight is considerably reduced by the employment of these blades.

Parseval II. had the following dimensions :—59 metres long, 4,000 cubic metres contents, 114 H.P. motor. The 1910 sporting ship is 39 metres long, 8 metres largest diameter. The covering consists of a double cotton fabric which will stand a pressure of a ton on the square metre and weighs only 300 grammes per square metre. The gores are placed horizontally, which improves the appearance and reduces the skin resistance. Only one ballonet is used, placed in the middle, the ascending and descending being accomplished with planes.

The propulsion consists of a 25 H.P. 4 cylinder Daimler motor running at 1,200 revolutions per minute and using less than 10 ounces of benzine per H.P. hour at full speed. The speed of the propellors is 300 revolutions. The latter are kept extended, even when the motor is still, by means of springs. The speed of the ship is about 16 miles per hour.

I shall next deal in a few words with the semi-rigid type. To prevent the balloon from collapsing when the air bags do not fill rapidly enough, and to get better means for hanging up the gondola, a rigid frame or keel is carried below the balloon. This frame is usually made of aluminium or wood. Otherwise these ships are constructed similarly to the non-rigid types.

Finally I shall deal with the rigid airship of Count Zeppelin. It has a light polygonal girder running from stem to stern, about 130 metres long and 12 metres in diameter. The weight of the girder makes a great volume necessary, and to obtain this without increasing the head resistance unduly, the body is given a great length compared with its diameter, in the ratio of over 10 to 1. A single container of this shape would be subjected to dangerous surgings of gas to and fro as either end rose and fell, so Zeppelin adopted a number of small balloons, 16 to 18 in number, separated from one another by partitions, and from the external covering of the balloon by an air space which serves to insulate the gas from the changes in temperature of the atmosphere. The covering for the balloon consists of a double cotton fabric, provided with several layers of rubber. This is preferable to a single thick layer, as it is practically impossible to have two pores in the same place in different layers. With 8,000 square metres of fabric it was found that the loss of upward pressure was only 24 kgs. per day. This, of course, will be somewhat increased when the balloon is subjected to vibrations, as the coverings will act similarly to sieves. The total contents of the ship is about 15,000 cubic metres, with an upward pressure of 16,000 kgs. at sea level. The weight of the ship is 11,000 kgs., leaving 5,000 kgs. for passengers, equipment, ballast, etc. The first model was somewhat smaller, and the motive power was only 16 H .P. The ship had no damping planes and the ascending and descending was accomplished with the aid of a weight, to be shifted on either side of the centre of gravity. Each separate balloon was provided with safety valves; air ballonets are not required, since excess pressure is communicated to the rigid frame. A number of balloons also carried operating valves. The cars or gondolas were fixed below the keel, the propellors were attached in the proper places, *i.e.* in the plane of the centre of wind pressure.

In the second model, damping planes were provided, for lateral steering rudders were still placed below the keel. In the third ship, the rudders were placed between the damping or balancing planes; later on, a finlike plane was added. The fourth ship, which was destroyed after a very successful trip, and after an effective landing at Echterdingen, had various rudders added, especially one at the prow. This, however, did not act, which may be explained by the presence of an air cushion which is moved along with the ship, so that a rudder, fixed here, is useless.

When it was placed at the stern it acted splendidly. In the next design, the ship was provided with box-shaped rudders; in the following one with rudders arranged in Venetian blind fashion.

The rigid type of balloon has the great advantage that propellors and steering gear can be attached in the most favourable positions, so that indenting of the balloon is impossible, if danger occurs to one or more of the separate balloons, it can still float, and air ballonets are not required. The ship is thus altogether better provided against the elements, once it is on its course, than the non-rigid or semi-rigid types. It has the disadvantage that a much greater weight has to be carried, requiring enormous dimensions, and that landing on *terra firma* was at first a dangerous thing. With the improved steering gear, Zeppelin proved that the landing is not at all difficult. The accidents which Zeppelin had were nearly all due to bad luck. At Echterdingen, it was due to an electrical discharge from the framework setting the gas on fire, aided by the gale which was blowing when the ship seemed safely landed. The military ship was wrecked on account of imperfect anchorage,the cart, used as an anchor, being pulled out by a heavy gale and the ship setting off on its own account. The *Deutschland,* the passenger ship Z7, was partly wrecked on account of want of fuel for the motors, and Z6 was burnt in the shed owing to the carelessness of an *employé* coming near the motor with a bucket of benzine, which was set on fire by a spark. Once proper care is taken in the handling of the ship, and the country is properly supplied with landing halls, accidents will be largely reduced in number.

The ship carries two gondolas, each fitted with a 115 H.P. motor made by Daimler, weighing 1,000 lbs. These motors are heavy for their size, but they have the advantage of using comparatively little benzine. Each motor is able to give the ship a speed of 25 miles an hour and both together of 32 miles. They may be run in either direction. The ascending steering gear is such that, if the planes are inclined under an angle of 15 deg. at 32 miles an hour, the lift is nearly a ton. The propellors are made of aluminium fixed to steel bosses. Zeppelin favours small propellors running at high speeds. All bearings are of the steel ball type. Behind the motors are placed the cooling tanks. Each cooler is in turn cooled by a ventilator. Above each motor is an oil vessel from which the oil passes to the lubricators by gravity. The motors work otherwise practically in the same way as those of motor cars. Besides the fuel, oil and water, for the motors, each ship carries a number of water bags supplied with valves and hoses as ballast. In the forward gondola are all the apparatus for steering the ship. There are three hand wheels for the rudders, two for ascending and descending. The former may be manipulated separately and jointly, the latter jointly only. The rudders and planes are operated by means of steel ropes which are conducted over rollers between the gas balloons and the external covering, and attached to the planes by means of pulleys of aluminium. Communication between the gondolas takes place by tin letter boxes and bells pulled by wires. A board carries the

necessary instruments. For landing on the water the ship is provided with water anchors, consisting of frames covered with cloth. For landing on dry land, ground anchors are supplied, and under each gondola is placed an air cushion to reduce the impact of the ground. As the gondolas are keel shaped the impact on the water is negligible.

The crew of such a ship consists of two trained conductors or captains, one first officer or steersman, also able to conduct, with three lieutenants, of whom one at least is an engineer; two sub-conductors in the second gondola, of whom one is an engineer; finallv for each motor, two mechanics; a total of 12 persons.

The invention of the present day aeroplane is due to a German, the engineer Otto Lilienthal, who shared with Zeppelin the misfortunes of the proverbial prophet. To Lilienthal is due the arched sustaining surface, and his investigations on the same—translated into many languages—still form the basis of present day designs. He also invented the glide flight, *i.e.* the method of learning how to sustain oneself in air; and finally, it was Lilienthal who was the first person that ever proved that flying was not an impossible thing.

The day, says the famous French aeronaut Ferber, on which Lilienthal flew for the first time over a distance of fifteen metres, may be considered the dawn of the era of human flight.

The brothers Wright in America were also disciples of Lilienthal, and when the latter was unfortunately killed in 1896, Wilbur Wright took up his work. The admiration of the brothers Wright for Lilienthal was admirably expressed by Orville Wright during his stay in Berlin a year ago, and when Ferber was last at Berlin, he went out to Lilienthal's grave and deposited a wreath with the inscription:—

"LE CAPITAINE FERBER,
A SON MAITRE LILIENTHAL."

It is not my intention to give a description of Lilienthal's and the Wrights' earlier experiments. Both built man-carrying gliders, with which they slided down slopes of hills on the top of an opposing wind which acted as an inclined plane.

Let us see how it is at all possible for a surface to sustain itself in air. If we take a sheet of paper and move it rapidly downwards, the sheet being horizontal, we experience an upward force. As the air underneath the paper has to be set in motion, work has to be done. In other words, by the movement of the paper the resisting air causes an upward force. An upward force is also produced if the air is brought under the sheet of paper, which is held stationary, and if the upward force is equal to the weight of the paper, the latter will float.

It might now appear that we ought to be able to sustain matter heavier than air if we employed surfaces which were moved rapidly downwards flatways on. Unfortunatelv, these surfaecs cannot be innumerable, so that they would have to be moved upwards in some collapsible state in order to become always available. Such apparatus have been built, but their efficiency is

extremely low, as a simple consideration will show.

Let P = total force of all downward directed planes,

V = the velocity.

then the work to be done is $P \times V$.

and if P is in kgs., V in metres

$$H.P. = \frac{P \times V}{76} \text{ horse power.}$$

As $P = G$ weight of planes, we get $\frac{P}{H.P.} = \frac{G}{H.P.} = \frac{76}{V}$, *i.e.*, by 1 H.P. we can carry the more weight, the smaller we make the velocity with which the planes are moved.

Now in the present day aeroplanes $\frac{76}{V}$ = 10 to 15, *i.e.* V must be 7.6 to 5 metres per second.

The question is what must be the size of the planes? To find this we must know the resistance of air.

This resistance increases (1) proportionally with the area of the opposing surface, (2) the weight of air, (3) the square of the velocity. If we double the latter, the resistance increases fourfold. This may be explained as follows:—By doubling the velocity, the particles of air are given double the velocity, but at the same time the surface gets into contact with double the number of particles.

We may therefore express the resistance of air by a formula.

$P = 0.6\ FKV^2$, in which

F = resisting area,

V = velocity.

$$K = \text{constant} = \frac{\text{specific weight of air.}}{\text{acceleration of gravity.}} = 0.125$$

The factor 0.6 is an experimental constant and expresses the efficiency.

We obtain thus

$$\frac{P}{F} = 0.6 \times 0.125\ V^2 = 0.075\ V^2$$

For $V = 7.5$ metres per second.

$$\frac{P}{F} = 0.075 \times 7.5^2 = 4 \text{ kgs. square metre.}$$

In order to obtain such a machine which will carry 500 kgs., the area must be $\frac{500}{4} = 125$ square metres. This area must always be available, so that—since the sustaining surface has to be moved upwards in a collapsible state to make it available over and over again—the necessary surface is really 250 square metres. For a weight of 500 kilogrammes this surface would be too flimsy and collapse at once.

Fortunately better results are obtained with inclined surfaces moved sideways.

Experiments show that, if we move a plane surface horizontally while it descends, the carrying capacity is increased mani-

fold. If the surface is cambered, this capacity increases seven to eight fold. Only these discoveries have made flight possible. It may be explained as follows:—We can set up a continuous relative force P only if we keep particles of air continually on the move. In the case of an inclined plane we set more particles of air in motion than with surfaces directed vertically downwards, hence the greater carrying capacity. The cambered surface is even better than the inclined plane without increasing materially the air resistance. We may express the carrying effect by a formula similar to the one for the air resistance.

We have $P=0.56\ KFW^2$, where W = lateral velocity. The force T, necessary to move the plane laterally, is about $\frac{1}{8}$ of P, or

$$T=0.07\ KFW^2 \text{ and for } K=0.125$$

we get

$$HP=\frac{P\times W}{76}$$

$$\frac{P\times W}{8\times 76} \text{ or as } P=G=\text{weight.}$$

$$HP\ \frac{G\times 20}{608} \text{ whence } \frac{G}{HP}=\frac{608}{W}$$

For $\frac{G}{HP}=15$, *i.e.* for 15 kgs. per square-metre surface we get

$$\frac{G}{HP}=15=\frac{608}{W} \text{ or}$$

$$W=\frac{608}{15}=40.5 \text{ metres per second.}$$

The carrying capacity of 1 square-metre is then found as follows:—

$$P=0.56\times 0.125FW^2$$
$$P=0.07\times P\times W$$

$$\text{but } P=G=\text{weight, hence } \frac{G}{F}=.07\ W^2$$

with W = 40.5 metres per second (91 miles per hour)

$$\frac{G}{F}=0.7\times 40.5^2=115 \text{ kgs.}$$

Even with W = 20 m/ sec. (45 miles per hour) the carrying capacity is $\frac{G}{F}=.07\times 20^2=28$ kgs. per square-metre, which is a decided progress over the vertically downward directed motion.

The means for rapidly moving cambered surfaces have made flying possible.

A high speed is directly desired, as we have seen. If we add one or more inclined surfaces, which are rapidly moved in order to produce the necessary reactive force, *i.e.* which will give the

design the necessary speed, the solution of flying is solved. This speed is obtained by means of so-called propellors, also designed on the principle of the inclined plane. In this way we obtain the aeroplane.

The action of the aeroplane is as follows :—By setting the motor going the propellors throw air backwards, which causes a reactive force that pushes the aeroplane forward. The latter commences to run if allowed to do so. The arched sustaining surfaces thereby throw air downwards, which produces a reactive upward force; and when the lateral speed is high enough, so that the reactive upward force is equal to the weight of the whole machine, including pilot, the machine rises. We see that the aeroplane cannot rise on the spot, but is obliged to make a start by first having a run. If the velocity increases still further the machine keeps on rising. Each machine is, however, limited to a certain height independently of the steering mechanism. The horizontal travelling of an aeroplane may be compared with the hill climbing of a motor car. If the motor is stopped the aeroplane would glide down the natural angle of descent. As $T = \frac{1}{8} G$, the angle of descent will be about $\frac{1}{8}$.

To keep horizontal the motor has to overcome gravity. To make it rise, additional work must be done, *i.e.* the speed of the motor must be increased. This speed is limited. Moreover the higher the regions, the thinner is the air; hence, in order to move the same mass of air, the speed must be still further increased if the machine is to keep on rising. Consequently, no further rising will take place when the increase in speed, which the motor can give, does not more than counterbalance the reduction in the weight of the air moved. If the same motor is to lift the aeroplane still higher, the only remedy lies in the cutting of the wings, *i.e.* the sustaining surfaces.

Consider now the stability and steering. We distinguish between longitudinal and lateral stability. A machine is stable longitudinally when the centre of wind pressure coincides with the centre of gravity. The latter is largely fixed, except for the pilot. The former varies with the speed. If the latter is increased, the centre of wind pressure moves forward. This the pilot has to watch. He can alter the non-stability somewhat by moving his body. To make the stability more secure, aeronauts use elevators and fixed tails, and in most cases warp the wings. The action of the elevators is as follows :—

When the speed is sufficiently high the elevators are so placed that the air strikes underneath. This manœuvre takes place to make the aeroplane rise. To descend, the reverse takes place. With a tail the same result is obtained or improved. The warping of the wings is done for similar reasons. If the wings are flattened, the angle of incidence reduced, the wing drops there. If it is warped so that the air strikes underneath, the wing rises here. It will be obvious that such warping may also be employed for lateral stability. This warping is also resorted to for turning. By increasing the angle of incidence the resistance is increased

and this part of the machine slows down. In addition to the warping, rudders are fixed to the elevators or the tails.

Lateral stability may be increased by the agility of the pilot and by lateral curtains, as in the Voisin biplane. Automobile stability is not yet employed, although a number of patents have been granted. The brothers Wright employ in one of their patents compressed air, forced against planes. Gyroscopes have also been thought of.

Of great importance is the proper working of the motors and the greatest care must be exercised in their construction. They must be very light ($1\frac{1}{2}$ to 3 kgs. per H.P.) and very reliable. The stopping of the motor would be of little importance if thereby the centre of wind pressure were not changed. It is this which the pilot has to watch and to counterbalance.

A great deal depends also on the propellors. They should be as smooth as possible, to reduce friction to a minimum, and the pitch of the blades should be such that no part is a drag on another. Large slow speed propellors yield better results than small high speed ones.

SPEKBOOM.—Mr. Ernest E. Galpin, writing to Mr. J. Burtt-Davy *apropos* of the latter's observations regarding the occurrence of Spekboom in the Transvaal Province (vide page 264 of this volume) remarks that it occurs well inland of both the Amatolas and the Kologha Range—the next higher plateau. He goes on to say: "It grows on the banks of the Zwart Kei River, close to its junction with the White Kei, in the Cathcart District, and it is quite likely that it crosses the river and is on the Queenstown side. The country is very wild, rugged and inaccessible in the neighbourhood of the junction of the Kei Rivers, and quite a Karroo flora follows the deeply eroded valley of the Kei right into the Queenstown District, with such plants as *Rhigozum trichotomum, Capparis albitrunca, Schotia speciosa, Azima tetracantha, &c.*

HALLEY'S COMET.—During April and the early part of May this comet was still being closely observed by Prof. Barnard, its magnitude in April being 15. Mr. F. Slocum a few weeks ago obtained a good photograph with a 2ft. reflector after one hour's exposure, in which it showed brighter than on September 11, 1909, although its solar distance was 110,000,000 miles more than on the date mentioned, a proof of the persistence of the physical brightening at perihelion.

ANCIENT COPPER MINE NEAR D'SJATE.

By Henry Alexander Spencer, M.R.C.S., L.R.C.P.

On the hill-side of one of the outliers of the Lulu Mountains, in the valley of the Mopetsi River, Lydenburg, and perhaps five miles from the residence of the Rev. Mr. Winter at D'sjate, I visited an old working where, probably very many years ago, copper ore had been quarried and smelted.

For two years this old mine had been worked by two men, one of whom was my companion, and had only been relinquished a year or so before our visit.

The old mine lay about half-way up a steep hill-side, into which it cut at about a right angle with the surface. Outside the adit was a rubble heap of considerable thickness, partly the refuse of the old working and partly the additional dump of the recent workers, who had sunk a perpendicular shaft through it to a depth of over 30 feet. Mr. Massey, my companion, had told me that when working this mine they had turned up "hundreds" of what appeared to be stone hammers, with deep grooves in them, so that I first set myself to find some of these palœolithic curiosities. Three were soon found which combined all the characteristics of their kind. These characteristics consist in their being rounded, heavy, crystalline rock, such as were to be found in any quantity in the river bed about two miles away. Some of the surfaces of these stones, if not all of them, showed smooth, worn concavities of varying size and depth, but always in the centre of that surface; these depressions and concavities have the appearance of having been ground or worn out of the surface by some hard substance which was fairly smooth and concentric. It is extremely probable that they were held in the hand, for which purpose they are all exactly sized and could comfortably be grasped in one hand whilst they were used as hammers. A rather surprising thing is that although the natives of this district know nothing of the workers in these copper mines, which abound in that and the neighbouring valleys, the use of these stones they attribute to the workers in the mines having hammered stakes of wood, hardened in the fire, into the rocks to split them, used, in fact, as crowbars are to-day, *i.e.* driven in between the layers of the rock and used to prise pieces off. This use of the stones would exactly account for the appearance and position of the concavities, hammering any harder substance than hardened wood being sure to cause chipping. The formation of the rock here, and I learn also in other similar mines, would readily lend itself to this treatment. None of the natives, however, have any knowledge of such stakes having been found, describing the working of these mines as long, long before their time and that of their fathers. The stones give no indication whatever of having been fastened in any way to a stick and used like a modern hammer; but many of them appear to have been discarded on account of chipping of their surfaces in a way which would interfere with a

true blow upon a stake, whilst some appear from the depth of their concavities to have long withstood the use they were put to and every side of them to have been similarly used. The shaft of the working was filled in with rubble almost to the top, but there were interesting evidences of the manner in which the ore had been smelted to extract the copper; and pieces of slag resulting from this process are to be found in every direction over the face of the country thereabouts, from this and other workings; I picked up pieces of slag at the roadside and in the beds of streams which I crossed, as well as at the site of the workings. Mr. Massey was able to inform me that he had crushed pieces of this slag and found in them beads of copper of the size of a pin's head and slightly larger. This would of course be too small in amount to be collected by those who worked these mines, the larger amounts having been in some way separated from the slag and collected; it is, however, evidence of its being slag from these workings, and that they did smelt the ore for copper on the spot.

At this mine the evidences of smelting still existed in a slab of rock on one side of the entrance to the adit. The slab was continuous with the rock of the hill-side, but some two feet below it a natural cleavage of the stratum had been widened and a rough tube of burnt pipeclay from the river inserted beneath it, and in some way not now evident carried up to the fire on its upper surface behind. A funnel-shaped piece of earthenware piping was attached to this tube under and round the slab, which was probably connected with some kind of primitive bellows, so that a blast could be kept up in the furnace above, and the ore thus reduced.

Mr. Massey was able to explain this to me from the evidences he found at this mine when he first went there, but most of which had since been destroyed. He showed me the slab which at that time was covered with slag and still showed the piping under and round the back of it.

The funnel-shaped piece of piping described I saw at the Rev. Mr. Winter's house and recognised it as of the same material which is at present used by the Swazi natives living all round there, for the manufacture of their beautiful pots and which abounds in the beds of the spruits.

Thus the stone hammers demonstrate how the quarrying of the ore-carrying rock was carried out—the slag that this was smelted on the spot—and the earthenware piping how the smelting was performed; in what age and by what race this mining for copper was conducted is still, however, a matter of much speculation and conjecture.

DECOMPOSITION OF WATER BY ULTRA-VIOLET RAYS.—A. Tian, in the current volume of *Comples rendus*, pp. 1012-1014, describes the effects of ultra-violet rays upon water. Decomposition into hydrogen and hydrogen peroxide takes place in the first instance, the latter being then in turn decomposed and oxygen evolved.

ON THE ALTERNATE VOTE AND THE ONLY CORRECT METHOD OF USING IT.

By John Brown, M.D., C.M., F.R.C.S., L.R.C.S.E.

This alternate vote must not be confounded with the transferable vote. Both may be transferred when necessary; in both the voter expresses a second choice, but the alternate vote is used only in selecting one member or official, while the transferable vote is only used when more than two members are to be elected. They are thus quite distinct and totally different.

This paper is practically a synopsis of one by Professor E. J. Nanson, of Melbourne University, extracts of which are published in two English Blue Books, Cd. 3501, 1907, and Cd. 5163, 1910. After some introductory remarks and definitions in *Sections* 1—12, the seven usual methods of electing one candidate or official are given, with a concrete example by Professor Nanson showing that they may fail to give a correct result, that is to select the candidate most fit in the opinion of the majority of the voters: *Sections* 13—20. Then in some detail is given Professor Nanson's proof, that under his method the candidate most preferred cannot be thrown out at the first count, when of course he easily secures the first place at the second. This is the essential point, where other systems fail: *Sections* 21 *and* 22. An illustrative example of Nanson's method of selecting the best of three candidates with its four varieties follows: *Sections* 23, 24. The four *Sections* 25—28 describe Nanson's method with more than three candidates. Its absolute correctness, the wide field of its application, and the necessity of its adoption are then mentioned.

SUBJECTS OF SECTIONS.

1. Recommendation of the Royal Commission Cd. 5163, 1910.
2. Selection of an official one of three applicants.
3. Besides voting for one candidate, a second preference must be given.
4. The original vote does not necessarily indicate the best man; the man the majority of the committee think most fit may be thrown out at the first count.
5. The essential point is to retain him at this first count. This is done in Nanson's method, and under certain circumstances in the Venetian method.
6. The three methods of counting used.
7. Definition of "Best man."
8. Absolute majority for one of two, or of three candidates on the first count of original votes (section 23).
9. Absolute minority:—when, counting all the votes and all the preferences a candidate has fewer than half the number of voters.
10. Of any three members, one is greater than the mean or average, one is less; the third may be the mean, or may be greater or less.

11. The correct expression for all the preferences of three men for three candidates.
12. No plan of selection will be found efficient unless it secures that the best man is retained at the first count, and gives an original vote a higher value than a subsequently expressed preference.
13. Enumeration of the seven incorrect usual methods.
14. The single vote method described and shown liable to error.
15. The double vote method similarly treated.
16. Borda's method similarly treated.
17. The French method or double ballot similarly treated.
18. Ware's method similarly treated.
19. The Venetian method similarly treated.
20. Condorcet's practical method similarly treated.
21. Nanson's method.
22. Nanson's proof, that under his method the best man cannot be rejected at the first counting in the case of three candidates.
23. First variety election by absolute majority of original first votes (8). Second, exclusion on receiving fewer combined first votes and preferences than the number of half the voters (9). Third, exclusion of two receiving less than the average on a list where first votes count two and preferences one (sections 21 and 10); if only one is below the average he is excluded and his expressed preferences elect one of the other two (21).
24. Illustrative example.
25. More than three candidates. In Nanson's third list, if first votes have a greater value than preferences, all below the average may be excluded: and all votes and preferences on the remaining list must then be altered.
26. The preference for the first vote may be expressed by giving it a less value than the second, counting it as one and the second preference as two; in that case we must exclude all who receive the average or more.
27. In cases of more than three candidates we continue scrutinies till all but one candidate is excluded, or till one has an absolute majority of first votes.
28. Tabular example with more than three candidates.
29. This is the only correct mode of securing an accurate result.
30. The working of the transferable vote for the election of more than two candidates is simpler.
31. The absolute correctness of Nanson's method in all cases, and its simplicity should secure its universal adoption.

1. The Royal Commission on Systems of election* state in their conclusions:—

"We recommend the adoption of the Alternate Vote in cases where more than two candidates stand for one seat,"

*1910. Cd. 5163.

and on the next sheet print extracts from a paper by Professor E. J. Nanson, of Melbourne, which describes the only way in which this vote can be effectively applied.

2. We shall consider this matter first where there are three candidates, or where a committee has to select the best of three applicants for any post, a matter of daily occurrence. As the methods and rules are exactly the same whether a large Parliamentary constituency is electing one member from three candidates, or a small every-day business committee is selecting one official from three applicants, we may keep the latter more familiar matter before our minds.

3. To secure the selection of the applicant, who in the opinion of the majority of the committee is the most fit for the post, every member of committee must express, after marking his vote, his preference as to the other two applicants; he must signify to which of them he would wish his alternate vote to be given, in the event of the applicant he has voted for being excluded or eliminated. This alternate vote is only used under these circumstances.

4. We shall see that the original vote does not necessarily show which of the three applicants is in the opinion of the majority of the committee the most fit for the post; and, that under the methods usually employed, it is possible for this best man to be thrown out at the first count. If he is not thrown out at the first count, his superiority easily secures his election, when he and the third applicant are left in the field.

This, the retaining in the field of the man who is in the opinion of the majority of the committee the best man, is the essential point. Nanson proves clearly that his method does this, and that the seven usual methods, which he describes, do not ensure this; though one of them, the Venetian method, under certain circumstances does so (12).

6. Some of these methods count only the first vote, taking in the first count no cognizance of the preference for the better of the remaining applicants; others count this preference, and put it on an equality with the original vote. Nanson's method and Borda's method allow, quite properly, a higher value for the original vote than for the alternate vote, or second preference in the first count; and Borda's method just fails, by the selection of the man with the greatest number of votes, in place of the exclusion of the man with the fewest votes (12), (15), (16), (20), (22).

7. I shall use the expression "best man," for the applicant who in the opinion of the majority of the committee is most fit for the post; for the highest candidate or applicant.

Glance for one moment at the state of matters when there are only two applicants: if "P," one of those applicants, secures the votes of three out of a committee of five, he has more than half, or an absolute majority, which at once secures his selection.

If when there are three candidates one of them secures one more vote than half the votes, he is evidently the best man. If "P" got three votes, and "Q" and "R" each only one vote, "P" is evidently better than each of them, and so would be

selected at once on his absolute majority, the other two being thrown out at the first count. However large the committee or the constituency, one vote more than half the votes given secures the election of the best man: this is on the count of the first votes. The counting or addition of preferences cannot alter the fact, that one more than half the committee think him the best man. There is no need to go any further, the selection has been made on the original votes alone; the majority is so decisive, that alternate votes could not alter it. No applicant, whether there are two or three, can get more votes than the man who has one more than half the votes or *an absolute majority*. This is the first case—the absolute majority case.

9. If, in counting the number of all the original votes and the expressed second preferences or alternate votes for each one of the three applicants, we find that one man has fewer votes than half the number of voters; that is, fewer than a quarter of all these combined original and alternate votes (which, as each committee man gives one of each, comes to twice the number of the committee), we are certain that man is not the best man.

To ask a committee man to vote for two out of three applicants, is the same thing as to ask him to vote against one applicant. If $2n$ is the number of committee men, and one candidate gets less than n votes, out of all the votes, original and alternate, it is clear there are more than n voters against him: it is evident that more than half the committee think him worse than one at any rate of the others. It is absolutely certain that he, with less than a fourth of the combined original and preference votes, is not the best man, and so he may be thrown out; having absolutely no chance of beating the best man, under any circumstances whatever.

If in a committee of twelve giving twelve votes and twelve preferences, one of the applicants has less than six votes, say five, that shows that more than six, say seven, do not think him the best man; he must be thrown out and his alternate votes distributed between the other two will settle which of them should be elected. This is the second case—that of the absolute *minority of the electors ascertained by counting the combined votes.*

10. If we take any three different numbers, and add them up, and then divide the sum by three, we get the average or mean; and of these three numbers one of necessity must be less than the mean, one must be greater, and the third may be the mean itself, or either greater or less than the mean; and in every case the one or the two that are greater exceed the mean by just as much as the mean exceeds the two or the one that are less than it. This of course is very evident where the middle number happens to be the mean:—thus 2, 3, 4,—3 is one-third of $(2+3+4)$ or 9, 2 is one less than 3, as 4 is one more than 3. So too in the more ordinary case, where the middle number is not the mean, say 2, 3, 5, which added give 10, and a mean of $3\frac{1}{3}$; 2 and 3 are below the mean, 5 is above it. 2 is $1\frac{1}{3}$ below the mean, 3 is $\frac{1}{3}$ below the mean, together $1\frac{2}{3}$, and 5 is just as much above the mean as these two are below it. So too 1, 4, 5, gives the same facts. I must apologise for this elementary arithmetic. You will

see its application presently (22).

If we express in three columns by the numerals 2, 1, 0, the vote and preferences of three committee men for three applicants, marking the vote as 2, the preference as 1, and the preference of both over the third by marking him 0, and add up these columns, we get a correct expression of all their preferences.

		A	B	C
Say P prefers A to B and B to C,				
Q prefers B to C, and C to A, and	P.	2	1	0
R prefers B to A, and A to C, and that	Q.	0	2	1
all mark their preferences as here given	R.	1	2	0
		3	5	1

Each line expresses three preferences, there are nine altogether. B is marked in the first line with one preference over C; in the second line with two preferences, that is with one over C and one over A; in the third line with two, one over A and one over C; that is five in all. A is marked in the first line with two preferences, one over B, and one over C; in the third line with one over C; three in all. C is marked in the second line with one preference over A; only one. A, B, C, have respectively 3, 5, and 1 preferences, nine in all. Thus adding up all expressed preferences gives us the number of preferences which each applicant obtains.

12. Before going concisely over the seven usual methods of selecting the best man, I would repeat the two essentials, which must be found in an effective plan: it must be impossible for the best man to be thrown out at the first count (5), and you must not only count all preferences, original and alternate, but you must give to the original preference a higher value than you do to an alternate one (6). I would bespeak close attention; for time and space forbids more than a simple statement of each plan, and a concise demonstration by a specific example of its possible failure.

13. The seven plans in general use are:—The Single Vote Method, The Double Vote Method, Borda's Method, The French Method of Double Elections or The Double Ballot, Ware's Method, The Venetian Method, Condorcet's Practical Method

14. *The Single Vote Method.*—The English Parliamentary method, one vote given to one candidate. In this method, unless one candidate gets an absolute majority, the result may be contrary to the wishes of the majority of the voters. Suppose three candidates, A, B, C, receive respectively 5, 4, 3 votes: A is elected. Yet, if the four electors who voted for B prefer C to A, and the three who voted for C prefer B to A, both of the defeated candidates, in a two candidate contest with A, would have defeated him by 7 to 5.

Here at the second count B is elected by a majority of 2; but if the 5 who voted for A prefer C to B, C should have been elected with a majority of 4.

Thus the Single Vote may fail to select the best man; he may be thrown out on the first count. It may fail whether you elect the highest or throw out the lowest. It may fail at the second count if all preferences are not fully expressed.

15. *The Double Vote Method.*—Each elector votes for two out of the three candidates, thus voting against the third, and the one who gets a majority of votes is elected. Under this method a candidate with an absolute majority as against all comers, may be rejected. Supposing the voting to be 4 CA, 3 CB, 5 AB, there are twelve selectors, and A, B, C, get respectively 9, 8, and 7 votes; A is elected. (Here we may say 4 CA or 4 AC indifferently (5), the relative position of A and C is a matter of no moment, the vote for the one is just the same as the vote for the other, and the expression AC does *not* mean that A is preferred to C, but merely that these two are preferred to the unexpressed third applicant B.)

Now suppose of the 7 electors who voted for C, each considers C better than A or B. Then, an absolute majority of the twelve voters consider C to be the best man; yet C is at the bottom of the poll.

16. *Borda's Method.*—Each selector has three votes, two of which must be given to one candidate, and the third to another. The candidate who gets most votes is elected. Say there are 12 selectors and suppose five prefer A to B, and B to C; that is five votes for AB, 5 AB, (note here and in Nanson's method AB expresses that the voter prefers A to B, and also prefers B to C, (6) the extra value given to a first vote is denoted by placing that candidate's letter first).

Say that two vote in the same way for AC, 2 AC, and five prefer B to C, and C to A, and vote 5 BC. Then, as the first of each of these three pairs has two votes to the other's one, the result will be A has 14, B has 15, and C has 7. B is elected. Yet seven out of the twelve electors preferred A to B and A to C; those namely that voted 5 AB, 2 AC. An absolute majority preferred A to B and also A to C, and in spite of that B is elected. The expression AB implies that both A and B are preferred to C, or more than C (6).

17. *French Method of Double Election.*—An election is held under the single vote method. If no applicant has an absolute majority of the votes polled, a second election is held of the two highest candidates.

We saw under the Single Vote Method, where 12 voters voted for A, B, C, respectively giving 5, 4, 3 votes, that if those 4 that voted for B prefer C to A; C, the rejected candidate both under the single vote and here had an absolute majority in his favour.

In this case further at the second election B would have had a majority of two over A; but if A's five voters preferred C to B, and A had been excluded then C would have had a majority of 8 to 4 over B. Thus at both stages the French system of the double ballot may give a false result.

In the next three methods voters express their preferences by writing the numerals 1, 2, 3, etc., opposite the names of the candidates in the order of their preference (6).

18. *Ware's Method.*—Each elector has one vote at every scrutiny. The candidates with fewest votes are thrown out one by one at each scrutiny and their alternate votes are transferred to the continuing candidate marked on it. Any applicant with

an absolute majority is declared elected, and the scrutinies are continued till one applicant has an absolute majority; if no applicant has that, the one with fewest votes is thrown out, and his alternate votes distributed. Here, as in the Single Vote at the first count, the best man may be thrown out.

19. *The Venetian Method.*—At the first scrutiny each selector has two votes, which are given 1 to each of the two candidates he most prefers, as in the double vote system. The candidate with fewest votes is rejected. We saw under the double vote that an applicant whom an absolute majority of the voters preferred may be thus rejected at the first count.

If there are $2n$ voters, and the candidate with the fewest votes at the first count has less than n votes, we saw before (*Section* 9) that he could not possibly be the best man, nor compete with the best man successfully, and that his rejection left the best man in; and in this case the Venetian Method answers, the best man is elected.

20. *Condorcet's Practical Method.*—At the first count one vote is counted for each first place. If any candidate obtains an absolute majority he is elected. If not, a second scrutiny is made, one vote is counted for each first place and one vote for each second place as in the Venetian Method, and the Double Method; and the highest applicant is selected. Suppose 16 voters vote as follows: 5 AB, 5 CB, 2 AC, 2 BA, and 2 CA. Then counting first votes only, we get A, B, C, with 7, 2, 7 votes, respectively on the first scrutiny, giving no absolute majority. The second scrutiny will give for A, B, C, counting first and second votes, 11, 12, and 9, respectively; thus B is elected.

Yet A gets a majority of two votes against B; for he gets 5 AB, 2 AC, 2 CA against 5 CB and 2 BA; that is 9 against 7 say A is better than B; and the same majority of two votes, namely 5 CB, 2 AC, and 2 CA against 5 AB and 2 BA, say C is better than B.

Having thus shown that the seven methods may be fallacious, we now come to the only effective method, *Nanson's,* which combines the principle of successive scrutinies with Borda's Method of giving a preferential value to the vote, or first preference, over the second preference or alternate vote (16), and makes use of the preferential voting paper, and excludes the lowest man.

21. *Nanson's Method.*—In the case of three candidates each elector marks the numerals 1 and 2 opposite the names of his first and second choice. At the first scrutiny two votes are counted for each first place, and one vote for each second, as in Borda's Method (16).

If the two candidates, who have the smallest numbers of votes, have each less than one-third of the votes, both are thrown out, and the third candidate, who has most votes, is elected (10).

But if only one candidate has less than one-third of the votes, he is rejected; his alternate votes are distributed to the two continuing candidates, and a second scrutiny is made to see who now has most first votes, and that candidate is elected. This is Borda's Method; but in place of electing the highest, as Borda

does, Nanson excludes the lowest (22).

22. Nanson then proves: that if one candidate A is the best man, he cannot be rejected at the first scrutiny, and is thus sure of being returned.

The whole number of electors is supposed to be $2n$. All vote for one of the three candidates, and express their second preference. Considering that all the $2n$ voted in regard to C and A, if d of them prefer C to A, then $2n$-d prefer A to C, since all express their preferences as to A and C.

I have ventured on some very elementary arithmetic. Perhaps some of us have forgotten our elementary algebra, so please bear with me once more.

Suppose a poor man has nothing in the world but one shilling in his pocket, which we shall call b, and the clothes he stands in, and that they are of the value of n. That one shilling is a positive quantity, and added to n makes n greater. Using the algebraical signs + for addition, and − for subtraction, b being a positive quantity, that is being more than nothing, the expression $n+b$ is more than n.

In place of having one shilling this man may be owing a shilling, be in debt to the extent of a shilling b. b is now no longer more than nothing, it is now less than nothing, it is a minus quantity, a negative quantity; and in estimating this poor man's estate b so far from making n more, makes n less; and $n+b$ becomes less than n. Remembering then that any quantity is positive or negative according to whether it is more or less than nothing, we may express the number of voters who prefer C to A by the algebraical expression $n+b$. That number will either be more than n, which remember is half the number of voters, when b is positive, or less than n when b is negative. In the case where it is more than n, b will be more than nothing, it will be positive. In the case where it is less than n, b will be less than nothing, it will be a minus quantity, and this being so $n+b$ will now be less than n. So now in place of d which we supposed to be the number of voters who preferred C to A, we may substitute $n+b$; remembering that when b is a negative quantity, or as we say when b is negative, that $n+b$ is less than n. and of course $n-b$ more than n. So much for elementary algebra.

We may say then those that prefer C to A number $n+b$; those who prefer A to C are therefore $2n-(n+b)$ or $n-b$. Let those who prefer A to B be represented by $n+c$, and of course then those who prefer B to A will be $n-c$; c like b being either a positive or a negative quantity. So also those who prefer B to C may be expressed by $n+a$, and those who prefer C to B by $n-a$.

Those who prefer A to C are $n-b$. Those who prefer C to A are $n+b$.

Those who prefer A to C are $n+a$. Those who prefer C to B are $n-a$.

Those who prefer A to B are $n+c$. Those who prefer B to A are $n-c$.

Using the expression AB for the number of electors or committee-

men, who put A first and B second, and similarly for other cases; and giving at the first scrutiny, as you remember (21), two votes for the *first choice,* and taking all the preferences expressed for A, all the first preferences AB and AC, and all the second preferences BA, and CA, we get for *all* the choices expressed for A, $2\ AB+2\ AC+BA+CA$. Now we may arrange this in the form $(AB+AC+CA)+(AC+AB+BA)$. In the first bracket we have put all the electors or committee-men who prefer A to B, and those were $n+c$, while in the second bracket we have all who prefer A to C, namely $n-b$. Hence on the first scrutiny we see that A's score is the sum of all his votes ... ... $2n-b+c$
In the same simple way it is shown that B's score is... $2n-c+a$
and that C's score is ... ... $2n-a+b$
A, B, and C's scores when added up of course gives us $6n$, as there are $2n$ electors, who vote for three applicants A, B, C giving a first rate, and a second rate or preference to each. The average of these three numbers is $2n$, and as we have seen before, in the case of any three numbers (*Section* 10) the highest candidate will have more than $2n$ votes, and the lowest, who will be rejected at the first scrutiny, will have less than $2n$ votes. When the votes are counted, the one rejected as lowest will not have more than the average number of votes.

By the above ingenious method of expressing the scores, which we have seen is absolutely fair, Nanson proves that if a majority of the electors prefer A to B, and also prefer A to C, A will on the above system of scoring get more than $2n$ votes. that is more than the average, and so will not be rejected at the first count.

The very simple proof is as follows:—Those voters who prefer A to B are $n+c$, and are by our supposition in a majority over those who prefer B to A, that is than $n-c$; thus c is positive, and $n+c$ more than n. Those who prefer A to C are $n-b$ and by our supposition are more than those who prefer C to A, that is more than $n+b$, so that b must be negative and $n-b$ greater than n. Hence, since $n-b$ is greater than n and also $n+c$ is greater than n, adding these $2n-b+c$ must be greater than $2n$, that is A's votes are greater than the average, and so he cannot be thrown out at the first count. Q.E.D.

Hence either B or C must be the applicant rejected at the first count, and A must win at the second, because according to our supposition he is better than B and better than C.

The great point is that with Nanson's method, the best man cannot be thrown out at the first count.

23. In actual practice Nanson makes use of the two cases we considered at the beginning of this paper, namely (*Sections* 8 and 9) that where, on counting the first votes an applicant has an absolute majority, and he is elected at once—first case; and that where, *on counting all the first and second votes,* the candidate with the least number of votes gets less than one-fourth of the combined sum—second case, that is, has the support of less than half the voters he is rejected, excluded, eliminated because he has an absolute minority.

By adding up the numbers used in these two counts—that of

the first votes and that of the first and second combined—one gets a third list, in which the first votes are counted twice, and the second or alternate votes once. For the first of the two lists contained the first votes only, the second contained first votes and second votes, and from this third list, on the third count, are struck off the applicants who get less than the average.

Say there are ten electors, and on the first count we find that A, B, C, respectively get the following number of first votes,
6 2 2 and the following second votes
1 1 8

A here has an absolute majority of the votes given and is declared elected: first case (8).

Take now another case where with ten electors the number of

	A	B	C	
first votes are as follows:	4	4	2;	no one has an absolute
majority, so we add the number	6	2	2	of 1st and 2nd votes,
getting	10	6	4	

Here C has only four out of twenty votes, less than one-half the number of electors—an absolute minority—so C falls out, and his two alternate votes are given as marked to A, who thus gets 6 first votes and is elected (9).

If now we add up all the first preferences in these

	A	B	C	
two cases, 20 voters, we get first votes	10	6	4.	No one
has an absolute majority, more than half the twenty votes; so we add up 1st and 2nd preferences getting 1st and 2nd preferences	14	12	14.	No one
has less than half the number of voters, so we add the two lines, getting	24	18	18.	Here

B and C are both below the average, so A is elected (23) and (10).

If B had received 20 votes, just the average, and C 16 votes, we should have eliminated or excluded C, as he has less than the average, and have distributed his four first votes, as marked, 3 to B and 1 to A. Thus A having now 11 first votes is elected in preference to B with 9 first votes (23).

In selecting the best of three applicants, we have thus four cases where we have absolute certainty that the one of whom the majority of the electors most approve will be selected:—

First,—where he has an absolute majority of their votes (8).

Second,—where an absolute minority of the electors vote by first and second preferences added together for one of the applicants, who is, therefore, rejected at the first count, and his alternate votes come into use at the next scrutiny, when on every voting paper the name of the excluded candidate is supposed to be erased; and his alternate votes are transferred to the other candidates (9).

Third,—where counting the first vote as two and the second preference as one, and adding both the first vote and the preferences up, we find that two of the three candidates have not secured the mean or average of all the votes; the third, being the highest of the three, is elected at once, without any transfer of

votes (23, 16).

Fourth,—where proceeding as in the third case two applicants are found to have secured more than the average, the third applicant having less, is excluded, and this third applicant's first votes are then given to the other candidates who stand as second preferences on each of his voting papers, and so the election is decided with absolute certainty (23).

CASE OF MORE THAN THREE CANDIDATES.

25. Note two important facts applicable to all cases of three or more applicants, when we have given the first vote or preference a greater value than the second preference or alternate vote, and added both these values up. The first of these is that as none of the applicants, who fail to get the average of these combined votes, can under any circumstances be the best man, they may all be excluded at once. More voters have voted against them than for them.

The second fact is, that if we have made a list of all the preferences expressed by the selectors or electors, and excluded all below the average, the figures expressing the preferences for a non-excluded applicant on our list have in every case to be altered, so as to show the actual value they now possess. As to the excluded candidates, not only does their alternate vote now come into play, so that the candidate marked 2 on their voting paper, or rather the next available candidate on their voting paper, has now to be marked one, but also the candidate marked 3 has to be marked 2, and all the lower preferences have to be altered as well in the same way.

A new list must in fact be made before the next scrutiny. Say we have eight candidates, each marked as under say on the first count that C, D, E have been excluded, the remaining or continuing applicants must be marked as in the lower line.

A	B	C	D	E	F	G	H
4	6	3	2	1	8	7	5
1	3				5	4	2

The relative value was shown by the unaltered figures, but for the next scrutiny we must have the actual not the relative value.

26. In considering the case of three applicants, Nanson following Borda gave to the first vote double the value he gave to the second (23); and he differed from Borda, when he excluded the applicant with least votes, the candidate or candidates who did not secure the average.

This very same difference in value of the first and second votes might have been expressed by counting the first vote or preference as 1, and the alternate vote or second preference as 2, and then excluding the candidate or candidates above the average, or the candidate who has just got the average; and this is the method he recommends when there are more candidates than three.

As many scrutinies are held as may be necessary to exclude all but one of the candidates, who is then declared elected. Here, as in the case of three candidates, if any applicant has at any scrutiny an absolute majority of first votes, he is elected without

any further steps being necessary. But if no applicant gets this absolute majority, all the candidates who secure the average or more than the average are excluded; their first preference votes are given to the continuing candidates according to the marking of the alternate votes, and in the next scrutiny their names are passed over as non-existent.

A	B		C	D	E	F	G		H	
1	2	1	3	4	5	6	7	2	8	3
1	2	1	5	3	6	8	4	2	7	3
6	1	1	8	7	2	5	3	2	4	3
3	2	1	1	5	4	6	8	3	7	2
8	7	3	6	5	4	3	2	2	1	1
8	4	1	3	1	2	5	7	3	6	2
8	7	3	6	5	4	1	2	1	3	2
4	5	3	8	7	6	3	1	1	2	2
8	7	3	6	5	4	3	2	2	1	1
8	1	1	2	7	6	5	4	3	3	2
4	3	1	2	1	8	7	6	3	5	2
59	41	19	50	50	51	52	46	24	47	23

In this table we have the expression of all the preferences of eleven selectors for the first eight applicants, out of a larger number. The sum of all the preferences is 396; this divided by 8 gives an average $49\frac{1}{2}$. A, C, D, E, F are above the average, and are excluded, leaving B, G, H as the continuing applicants, and their new actual value is marked in the figures to the right hand side of each space, the addition of these gave B 19, G 24, H 23. The two latter being above the average are thrown out and B is elected.

In this particular case at the second scrutiny B has 7 first votes, 7 out of 11, an absolute majority, so B's election might have been declared without considering any other votes (23).

This method seems complicated, but Nanson makes various practical suggestions towards making its application as easy as possible, even in the case of Parliamentary Elections in large constituencies.

29. It is the only method of securing a correct result with the Alternate Vote, the adoption of which the Report of the Royal Commission on Electoral Systems recommends.

30. The transfer and the counting of votes at a Parliamentary election under the transferable vote, where more than two members have to be elected, seems to me simpler; and this is one slight additional argument to the many strong ones in its favour, which the Report of the Royal Commission* contains, and which influenced Lord Lochee to add to it a note, in which he expresses the opinion, that the transferable vote is not only practicable, but is the simplest and best means of securing to elected legislative bodies a more fully representative character. He goes on to say:

"Under our present system a minority of electors may seat a majority of legislators. A small minority may elect a large majority. Considerable sections of the electorate may have no representation at all. It is impossible to say that such a system has a fully representative character, or to deny that the transferable vote would remove or greatly modify its defects."

31. This, however, is beside the present question, we are considering the Alternate Vote, and the selection of one member or one official, a matter not only of importance in three-cornered

*1910. Cd. 5163.

Parliamentary contests, but daily everywhere in electing the best applicant for every post or office. We have examined eight methods of selection, and I have given Nanson's proof that his is the only one sure in all cases to give correct expression to the wishes of the majority of the electors, and its application to the selection of the best of three candidates is simple and easy. It should therefore be adopted in every case.

NOTES ON THE MORPHOLOGY OF THE MAIZE INFLORESCENCE.

By Joseph Burtt-Davy, F.L.S.

(Abstract.)

Various abnormal developments of the maize inflorescence were illustrated and discussed. These included: (*a*) monoecism in the staminate infloresence ("tassel") of sucker shoots and (rarely also) of the main stem; (*b*) the branching of the pistillate inflorescence ("ear"); (*c*) development of staminate spikelets at the ends of the branches of an "ear"; (*d*) fasciation of the "ear"; (*e*) tendency of the ear towards splitting into spikes of distichous spikelets; (*f*) the development of secondary ear-bearing branches from the nodes of the upper primary ear-bearing branches; (*g*) the homology of the inflorescence of the lower primary branches ("suckers") with that of the upper primary branches ("ears").

The tendency of either form of inflorescence to produce branches, as also of either form to produce both staminate and pistillate spikelets, was commented upon. The author expressed regret that he had not opportunity to follow up the subject, but that he thought it desirable to place his observations on record for the use of those who might be investigating similar problems in other plants.

INTERNATIONAL INSTITUTE OF AGRICULTURE.—The third session of the Institute is to be opened at Rome by the King of Italy during June of the current year. Upwards of forty different states are represented in the Institute, and the statistical, technical, and economic information collected is regularly published in monthly bulletins. The latter appear in as many as five languages, and it is understood that the English edition is translated by Mr. W. P. Watermeyer, B.A., formerly of Cape Town.

OIL FROM TOMATO WASTE.—In a recent article on the waste products from some chemical industries, S. Fachini refers to the possibility of economically recovering oil from the waste in the manufacture of tomato sauce. It had already been proposed, with such an end in view, to subject the crude material to a preliminary drying process, but it is now suggested as more economical to agitate the waste with water, allow the seeds to settle, remove the latter and transfer them to a centrifugal machine, where they can be freed from the greater part of the adherent moisture. They are then to be dried, and the oil recovered by pressing or extraction, the last traces of the volatile solvent to be driven from the residue and from the oil by heated carbon dioxide gas instead of steam.

TRANSACTIONS OF SOCIETIES.

South African Institute of Electrical Engineers.—Thursday, March 16th: J. H. Rider, V.P.I.E.E., President, in the chair.—"Some Aspects of Theory": Sir W. H. **Preece.** The author emphasised the value of correct theory in hastening progress by enabling the brain to guide the hand. Viewing electricity as a form of energy, he briefly discussed the motion of electric waves, and the application of Newton's gravitation and Ampere's dynamic laws to electrons and atoms.—"Troubles on overhead Power Lines"; C. W. R. **Campbell.** Amongst the points specially referred to were the following: The decided influence of the geographical direction of the line; the faulty material of insulators, and the flashing over caused by lightning and, more frequently, by birds; objects blown or thrown over the lines and guard wires; the contraction of the line during cold weather; the wash out of poles from soft ground during heavy rain or their being rendered insecure by animals rubbing against them.

Geological Society of South Africa.—Monday, March 20th: Dr. E. T. Mellor, F.G.S., President, in the chair.—"Notes on the Steinkopf Beds in Namaqualand": J. G. W. **Leipoldt.** A geological description of a series of stratified sedimentary rocks, north-west of the Mission Station of Steinkopf, extending north and south for over 40 miles, and from five to ten miles east and west. To these rocks, which differ in character from the older formations of the north-west, the author assigns the name of "Steinkopf Beds."—"Some structural features of the Witwatersrand system on the Central Rand: with a note on the Rietfontein Series": Dr. E. T. **Mellor.** A system of strike faults of considerable magnitude in the Lower Witwatersrand formation on the Central Rand was described. The line of fault had a marked effect on the apparent succession of beds in the Lower Witwatersrand Formation, and would also modify the apparent thickness of other beds on the Central Rand. The author agreed that the Rietfontein Series belongs to a formation unconformable to the Witwatersrand System. "Petrological notes on the Kimberlite occurrences in the Pretoria District": Dr. P. A. **Wagner.** An account was given of the petrography of the rocks met with in occurrences of a basaltic Kimberlite in ten localities in the Pretoria District; observations were also recorded descriptive of the passage from yellow to blue ground in the Premier Mine, of four megascopically distinguishable varieties of blue ground, and of inclusions in and later intrusions into the latter. Fusion, and subsequent recrystallisation experiments on the highly serpentised blue ground from the upper portions of the Premier Mine, in order to test the possibility of thus obtaining a rock resembling fresh Kimberlite were also described.

Monday, April 24th: Dr. E. T. Mellor, F.G.S., President, in the chair.—"Notes on the occurrence of oriental ruby in Kimberlite": H. S. **Harger.** A description of crystals and fragments of ruby, about a dozen in number, picked out from the pulsator concentrates by sorters at the Koffyfontein Diamond Mine, and varying in weight between one and 7½ carats.

South African Institute of Engineers.—Saturday, April 8th: Mr. J. A. Vaughan, President, in the chair.—"Electricity as a cooking and heating agent": C. G. **Trevett.** In addition to dealing extensively with the initial outlay and the cost of current, maintenance and repairs, the author dwelt on the need for ensuring satisfactory insulation and on the selection of suitable utensils.

Royal Society of South Africa.—Wednesday, April 19th: S. S. Hough, M.A., F.R.S., President, in the chair.—"Photography as an aid to Astronomy": S. S. **Hough.** (Presidential address). A description of methods in use, and the progress made by their aid in securing the necessary data for the discussion of astronomical problems; in particular the advances rendered possible through the introduction of photography in this connection.

Wednesday, May 17th: S. S. Hough, M.A., F.R.S., President, in the chair.—"Some new South African succulents and other plants": Dr. R. **Marloth.** The author described a species of *Cytinus*, the second of the South African Rafflesiaceae; a *Borbonia*, the source of Cape "rooibos" tea; and an *Anacampseros*, another example of a mimicry plant.—"Notes on the language of Bushman tribes north of the Orange River"; Miss D. L. **Bleek.** The language spoken by these tribes differs too much from that spoken by the southern Bushman tribes to be called a mere dialectical variation. The author had also studied the peculiarities reproduced by the gramophone records of pure Masarwa, in the heart of the Kalahari, preserved in the S.A. Museum. "Notes on the result of investigation of a Strandlooper Rock-shelter": Dr. L. **Peringuey.** A description of objects found in a cave necropolis, including several skeletons, in the pelvic bone of one of which part of a stone arrow-head was embedded. Flat stones, occasionally painted, had been placed on the hunched-up bodies, and the evidence indicated that implements of the palæolithic and of the neolithic types were coeval, and that no hiatus existed between them in South Africa.—"Observations on the inheritance of character in *Zea mays*": J. **Burt-Davy.** Some results obtained by crossing different varieties of maize, and manifested in the red colouring pigment extending from pericarp to aleurone layer, and in the variation of the number of rows on an ear.—"On the early Babylonian eclipses of the sun": E. N. **Nevill.** The author disputes the correctness of Dr. Cowell's identification of the total eclipse of the sun recorded in line 14 of Tablet No. 35968 in the British Museum with that of July 31st, B.C. 1062, and finds that only three total eclipses satisfy the prescribed conditions, namely, those of June 5th, 1217, May 18th, 1123, and May 31st, 956.—"Sylvester's axi-symmetric unisignants"; Dr. T. **Muir.**

Chemical, Metallurgical and Mining Society of South Africa.—Saturday, May 20th: Dr. J. Moir, M.A., F.C.S., President, in the chair.—"Some aspects of mine ventilation and temperature on the Witwatersrand": J. **Whitehouse** and W. L. **Wotherspoon.** The paper was illustrated by charts and diagrams showing, from rock temperatures taken in deep level mines on the Rand, that the mean rise is 1 degree F. for 253.9 feet vertical depth, and giving a number of psychrometrical observations at various underground levels at the Village Deep mine. The effect of a fan installation was to extract from the mine as much as 202 tons of moisture per day, and the provision of a plentiful water supply for laying dust consequently becomes necessary. From an economic standpoint it was requisite to deal with the increase of temperature with depth in order that the miner's capacity for work might not be reduced.

THE LATEST REFORM IN THE UNIVERSITY OF PARIS.

By Prof. R. D. Nauta.

Thirty-five years ago, and before the definite inauguration of the rebuilt and renovated Sorbonne in 1900, higher education in France was still what it had been under the Second Empire and the July Monarchy: stinted, unsatisfactory, inadequate. There was then at Paris no University proper;* but there was a "*College*," there were "*facultés*," there were "*écoles*," twenty distinct and isolated establishments, having amongst themselves neither the same traditions nor the same origin. There were even several varieties of them. First of all, there were the professional schools, because society stands in need of physicians, lawyers, chemists, engineers, parsons, lecturers in secondary schools. The *école* or *faculté de droit*, the *école or faculté de médicine,* the *école de pharmacie,* the *école polytechnique,* the *école normale supérieure* and the *faculté de théologie protestante* were engaged in training and supplying them. Secondly, there were the establishments for scientific training, because fundamental initiatory schooling in the methods of investigation and original research, of which scientific progress is the outcome, is one of the primary essentials of higher education. The *Collége de France,* founded in the 16th Century by Francis I., the *Museum d'histoire naturelle,* created during the Revolution, and the *école des Hautes Etudes,* established in 1869, had been, all of them, created with the same object in view, namely encouraging study for its own sake and furthering the advancement of the speculative sciences. As for the "*facultés*" of science, letters, and Roman Catholic theology, which three were quartered in the Sorbonne, it seems likely, that they had been established neither for the training of lecturers (which was evidently the task of the *école normale*), or of priests (the Roman Catholic clergy being recruited from the diocesan seminaries); nor did they make the rearing of erudites and scholars their speciality (the *école des hautes études* having been entrusted with this task ever since 1869). To all appearance, the main reasons for their existence were the conferring of degrees, and the publishing and popularizing of works of high importance. Several other circumstances tended to increase the general confusion of the bodies called "*facultés*," only two distinctly owned the character of professional schools; the remaining three were athenæa without regular students. Besides, the teaching of some of the professional schools, *e.g.* the *école polytechnique,* had taken quite a speculative and theoretical turn, and the oldest institution for scientific

*The history of the University of Paris may be divided into four periods: I., from Philippe Auguste (1200) to the reform effected by Cardinal d'Estouteville (1452); II., from 1452 to the new reform in 1600; III., from 1600-1792, when the old universities were suppressed by the Revolution; IV., 1792-1900, when there was no university proper. A new era was opened in 1900, or rather in 1898.

research, the *Collège de France*, had gradually degenerated into an athenæum, pretty well analogous with the Sorbonne *facultés*. Of the *écoles*, some resembled externally the Colleges of the old French and foreign universities (say Oxford and Cambridge), so far as to have resident students, and consequently halls, refectories, dormitories and gardens. The école normale superieure and the école polytechnique were examples of this class. Others again were open to all and everybody, without even any condition of lawful matriculation, like the Collège de France and the Sorbonne, which latter had formerly been the Collège de Sorbonne. All these oddities and many more could be explained and even justified from an historical point of view, but in practical life they entailed a host of vexatious and undesirable consequences, among which a general incoherence, segregation, double chairs and others were unpleasantly prominent. Besides, these institutions, which had been made illustrious through the services rendered by great men that had once belonged to them, were, without any exception, placed under the guardianship of the State. The State duly provided for the upkeep of all the establishments of higher education; but there is no denying, that the State financed them on principles of strict parsimony and presided over them directly and without control. However, this chaotic and unsatisfactory state of affairs was to come to a close, a few years after the disastrous Franco-German war of 1870.

In 1875 a remarkable movement was set on foot. As a piece of good luck, certain men of high public spirit, inspired with an enthusiastic zeal for the general good, and keenly alive to the highly important part that science has to play in modern society, had been elected about that time to the high and responsible posts of Minister of Public Education, or Director of Higher Education in France. Now it happened, that in 1875, the then Higher Education of the State had to endure the brunt of a severe attack from the clerical party; the Church venturing in that year upon an attempt at competition, by creating Roman Catholic Universities. In this serious emergency, the secular representatives and champions of the State, on communing with themselves, had to acknowledge, that the general condition of public higher education was appallingly open to criticism. They now became aware, that the traditional organization was utterly unsatisfactory, and on the spur of the moment some of the Ministers of Education under the third Republic, firmly resolved to take the matter in hand with a view to serious improvement. They started with an unflinching purpose of stirring up and increasing scientific activity everywhere, and at the same time with the intimate conviction that the reform was to be best accomplished by properly arranging and grouping the scattered forces into great teaching bodies, to whom an appropriate material and moral autonomy was to be granted. These great teaching bodies, well endowed and adequately staffed, were to make it their task, to raise the old French and international name of "University" to its pristine honour and glory. Subsequently, the Ministers, Waddington, Ferry, Bert, Goblet, Bourgeois, the Directors du Mesnil, Dumont and Liard undertook to endow both "facultés" and "écoles."

They did this with an honesty of purpose, a generosity of intent, a perseverance, and a wise discretion, which are above all praise. They engaged in the arduous task of regenerating these bodies by the infusion of entirely new and healthy blood; they endeavoured to accustom them to self-management, they encouraged them to union and coöperation, and finally resigned a considerable protion of their own absolute authority for the sake of these newly associated institutions. Prepared for these changes by a series of eloquent writings, such as Renan's "Questions Contemporaines" and Lavisse's "Questions d'Enseignement National," and "Etudes et Etudiants," public opinion readily joined the chorus of applause. In due time Parliament voted the required grants and credits, and at the present day the country has been gathering for some time the firstlings of these high-minded endeavours, and of all this disinterested exertion.

At Paris the field of operation had been wisely limited from the very beginning. By general consensus of opinion, it was esteemed, that there could be no question of incorporating the *Collège de France*, the *Ecole normale supérieure*, the *Ecole polytechnique*, the *Museum* and the *Ecole des hautes études*, in the scheme under consideration. These time-honoured and world-famous institutions ought to be left untouched and taken into account only, whenever the question arose of increasing and expanding their resources and privileges. Thus it was stipulated that only the Ecoles or facultés of Protestant theology, of law, of medicine, of pharmacy, of science and of letters were to be associated and to henceforward constitute the "*Corps universitaire.*"

The first steps and measures the Republican State was prevailed upon to take in its touching anxiety for higher education and scientific culture, were of a purely financial character. And indeed there was proper urgency for its following such policy. The preceding Governments, however prosperous and brilliant they were, had done absolutely nothing, not even in Paris itself, in the way of endowing France with an appropriate scientific equipment of buildings, laboratories and instruments. Almost everywhere the buildings were wretchedly bad; nowhere could they be said to be even barely sufficient, says Liard in his "L'Enseignement supérieur en France."

> "My contemporaries [he continues] will never forget the cheerless, stuffy garret rooms of the old Sorbonne, the fetid and deleterious hotbeds of sepsis and infection of the dismal old Ecole de médicine; the sweating, mildewed and leprous walls of the old Ecole de pharmacie. The sum total of annual subsidies to all the laboratories of the science-faculté did not amount to fr. 10,000 [*i.e.*, not yet £420.] In all the departments, the professors and lecturers were sadly underpaid. All the establishments and installations looked hideous, unkempt, smutty and penurious, in comparison with those of most of the foreign universities."

However, in spite of the formidable burden, with which the débâcle of 1871 had saddled France, the Republican Government did not hesitate a minute to follow the policy of the late Prussian kingdom, which, although poor and uncommonly parsimonious, had never been found stingy as far as military and scientific expenses were concerned. It liberally rebuilt the Sorbonne and

the Ecole de Pharmacie; it isolated and considerably enlarged the Facultés of medicine and of law. It multiplied, stocked and equipped libraries and laboratories; it increased the number of chairs and worthily filled them. All the sciences are now splendidly housed owing to its liberality. The "*Montagne Sainte-Genevieve*" at Paris is nowadays one of the most expensive and one of the finest university quarters in the world. Even the non-university schools have not been forgotten. The *Ecole des Chartes* and the *Ecole des langues orientales*" have been rebuilt; the Museum of the *College de France* has been enlarged regardless of cost.

While thus, by the generosity of the *patres conscripti*, the necessary funds were gradually forthcoming, which were to enable the University of Paris to honourably hold its own in future among the universities of the old world and the new, the promoters of the vast scheme of reform that was going on were busily engaged in planning and mapping out the internal transformation of the "écoles" and "facultés." Four of these: protestant theology, law, medicine, and pharmacy, prepare their students; but the two *Sorbonne-facultés*—sciences and letters—had none. Naturally the question now arose how to draw students to these latter two. It was of the utmost importance that this should be contrived without either hurting the feelings or infringing the established rights of others. The thing in itself was simple enough. It would be almost sufficient to make known that in future these two *facultés*, as in the case of the école normale supérieure, intended to prepare for the licenciate and *agregation* examinations. These examinations, as is well known, grant the *jus docendi* as a lecturer in the system of secondary schools in France. The Ecole normale supérieure could not possibly take umbrage at this step, since it admitted only a strictly limited number of students to its courses every year, and had as yet never supplied the total number, nor even the majority of the *licenciés* and *agrégés*, wanted to staff the *lycées* and *collèges* of the country. By admitting such applicants as had been refused admission at the Ecole normale and the Ecole polytechnique, and moreover by opening their doors to those who had either not been willing or not been able to attempt the entrance examinations of either of these two, the *facultés* of sciences and of letters were certain to secure an excellent attendance of students, whose numbers were sure to increase vastly, if the military laws (as they actually did later on) were to grant special and desirable prerogatives to recruits, who entered the service with the title of either *licencié ès lettres* or *licencié ès sciences*. Thus it appears to be comparatively easy to attract legions of students by the decoy of professional training and preparatory schooling for State degrees. However, the reformers had nobler and loftier aims than those of mere piddling practicality. They deemed it indispensable that in the very first place these *écoles* should be *scientific*, without therefore ceasing to be professional. To quote Liard once more:

"It was desirable, nay necessary, that a scientific character, with all the sense of truth, and liberty of thought, all the faith in ideas and submission to facts, all the idealism in conceptions and

realism in methods that science involves, should be henceforth essential to these institutions. For two important reasons, this was imperative; namely: to successfully lead professional education, which these schools were to continue, back to its living source, and to enable these schools, in their turn, to take scientific progress firmly in hand."

The main object aimed at was to replace and supersede the demoralizing, low-level routine of cramming for examinations, which obviously leaves the student practically indifferent, passive, unexerted and unenlightened, by a free and intelligent initiation, on the broadest possible lines, to the methods as well as to the achievements and results of science. In order to accomplish this, there was only one way: modifying the syllabuses and programmes in such a manner and to such an extent, that in order to successfully pass the examinations prescribed for the divers degrees, it should henceforth be required of the candidate. not only to have stored a certain amount of notions and of positive knowledge, but also to have properly tested his intellect and his natural capacities. We can now see the reason why, from the beginning, the first step towards the reform of the *facultés* had to be a reform of the examinations. By introducing into the examinations and into the teaching leading up to them. an element of higher scientific order than hitherto; by raising the professional function of the *facultés* to the level of their scientific work, professional training was to become more scientific. In this way science would no longer be hampered by professional training, which had been hitherto a stumbling-block in its way.

On the strength of ideas like these, the rules and regulations for admission to the different degrees were gradually and progressively altered and modified in all the *facultés*. Almost everywhere, thorough and original work is strongly encouraged nowadays in the programmes of study, whereas formerly, the obligatory academic themata, which, by ministerial decision, had to be uniform for all the candidates and consequently for the masters as well, had severely handicapped such work and made it all but impracticable. It stands to reason, that this radical reform of the examinations, which was intended to bring about efficiently the metamorphosis of the *écoles professionnelles* and athenæa into truly scientific establishments, was not dictated by the central government. Enough for the government had been all the legislation in syllabuses and programmes that it had been compelled to go through during the past three-quarters of the century. Government confined itself to manifesting its desire, that the traditional drags and obstacles, which hampered the soar of the scientific spirit, should be removed. As for the practical steps and the details, competent corporate bodies were invited to consider them; and in certain cases, they were requested to take steps themselves, at their own responsibility and after approval from the central authorities. Decisions and decrees, says Albert Dumont, Director of Higher Education from 1879-1884, will not cause higher education to make any real and thorough progress. Progress is to be reached and achieved by changes, effected in the ideas. The teaching bodies must feel their high responsi-

bility; they must have confidence in their own authority; they must know how to speak up for themselves and to say what they want, and why they want it. Thus a sufficient impulse must be called into existence, morally to coerce the administrative powers to yield and follow suit. If the old faculties, deeply sunk as they were into their old ruts, where they felt pretty comfortable, had been left to follow their natural evolution, it is quite possible, that of their own accord, they would never have struck into the new paths, nor ever made a new departure. But after the incentive had been given by the upper quarters, and when the inevitable waverings and hesitancies had been overcome, they all marched briskly and cheerily towards the proposed ideal, which the majority of their members had been fostering in their inmost hearts, for a long time already.

When the scientific renascence of the *facultés* had become a self-accomplished fact, the moment for granting them certain rights seemed to have come. To begin with, their legal status with its attendant rights, which had been arbitrarily taken from them, or rather had been tacitly confiscated by the State, was restored to them in 1885, without any restriction or reserve whatsoever. Moreover, it was stipulated, according to the decision of the 28th of December of that same year, that in every academic centre, there should be a "*conseil général des Facultés,* consisting of the Rector, who was to act as its chairman, while being at the same time the representative of the State, the doven and two delegates, chosen among the members of each of the *facultés*. The task of this Council was to aim at appropriate and harmonious arrangement of the whole. It had to shape into a uniform *ensemble* the divers curricula of all the *facultés,* by grouping them together, in such a manner as equally to serve the interests of science and of study; by drawing up regulations for the free courses and scholarships, by expressing their judgments and opinions on the eventual transformations of vacant chairs, by judiciously dividing among the various *facultés* the amounts of the common credits, and by assuming jurisdiction over all the students from a point of view of discipline.

In the course of the ten following years, these preliminary measures acquired a god deal of precision; and the rough outline was got into distinct shape. The Financial Act of 1890 transformed into subsidies or grants, the annual credits, which the State allowed to each of the *facultés* for defraying its expenses, and entrusted them individually with the direct management of these sums. The Act of the 28th of April, 1893 conferred legal status upon bodies, formed by the welding together of the several *facultés de l'etat* into *one* academic centre. The Act of July 10th, 1806 finally gave to those bodies, along with the name of "university," a sphere of competence more sharply outlined and a more extensive autonomy. The author of the report of the Council of the University of Paris for the scholastic vear 1897-1898, records in the following terms the definite victory :—

"L'université existe; la discussion et la libre disposition d'un budget en commun, relient les différentes facultés. Nous n'avons plus le droit de nous désintéresser les uns des antres. Nos responsabilités sont communes et nos devoirs ont augmenté. . . . . ."

This then is a general and very sketchy outline of the history of the manner, in which the French universities, and particularly the University of Paris, have since 1875 developed into their present state.

Now let us see whether the hopes and expectations, which the Republic fostered with regard to this lengthy and difficult piece of work, have been justified by the results.

The six Parisian *facultés,* amalgamated in 1885, numbered at that period 171 chairs and 10,679 students. In 1900, the teaching staff of the *Université de Paris* amounted to 255 for 13,771 students. The *faculté des lettres, i.e.* the Sorbonne, had in 1877 only eleven professors for the exceedingly small number of six regular students. According to the most recent statistics, there are now over 52 professors and about 1,700 students. The maximum was reached in 1896, when the total number of students was 14,654 and the teaching staff 277, inclusive of the free courses, but this enormous figure has since gone down a little. However, there is nothing in a decrease like this to be uneasy about. Prof. Petit de Julleville, the famous philologist, points this out, when he rightly observes in his report to the Council in 1899:

> "If there is any branch of education that has to aim at quality rather than at quantity and number, it is higher education. The University of Paris, with her 13,771 students, is still the greatest in the world and the alma mater of about half the students in the whole of France. It would really not be wise to wish for an increase of numbers. Besides true progress, according to my opinion, lies elsewhere, namely in the continuous increase of intensity of study and in the greatest possible extension of the range of purely scientific research, which has not either immediate material profit or professional interest for its nearest and dearest object. There are indeed students enough, but there will never be study enough nor will there be too much science."

It requires no special mention, I think, that the cost of so huge an organization is enormous. Three-fifths of the annual expenses are met from the subsidies, granted by the State; the remainder is supplied by the students' fees, inscriptions and other sundry revenues of the University. But a good deal of additional capital is wanted. The buildings, libraries and laboratories are in quite a decent state, and from the revenue at its disposal the Council has already been able to found several chairs and lectureships that were wanting. Yet in America and in Germany, there are universities, which are better equipped than the University of Paris, and the daily wants are constantly on the increase. It were a thing devoutly to be wished, that still more were done in donations, legacies and voluntary contributions. Nowhere is the State more generous with regard to higher education than in France; but nowhere has the State to defray the expenses of higher education almost alone, to such an extent as there. Things have improved of late, now that the generosity of the public, which after finding its way so long and so faithfully to "*l'Institut,*" has also learned to know the way to the universities. Several chairs have been endowed, prizes, scholarships and travelling scholarships have been established by the Municipality of Paris and by private persons. After 1896 the University of Paris received even

truly royal gifts: the Nizza Observatory with its branch establishments, the station for marine biology at Wimereux, capital to such an amount, that the interest serves annually to enable five students or young doctors, to make a voyage round the world. Moreover, an association was founded in 1898, called a "Société des Amis de l'Université de Paris," which has for its object to further and promote the development of that University by the creation of additional chairs and lectureships, by subsidies to laboratories and libraries, by the organization of University extension work, outside the *facultés,* by founding scholarships, etc. Indeed, more has materialized than was hoped for. It seems to be in the nature of things, that examples of this kind are catching, and it stands to belief that the University of Paris, which has now become anew, what it was in the 13th century, the most populous university in the world, will be in all probability one of the richest forty or fifty years hence. She has resumed her place—and in the olden times this place was in the foremost ranks—among the universities of the world. Foreign as well as French universities have invited her to associate her illustrious self with their jubilees. Leyden received and feasted her delegates in 1875, Heidelberg in 1886, Bologna in 1888, Montpellier in 1889, Lausanne in 1891, Dublin in 1892, Philadelphia in 1893, Halle in 1894, Glasgow, Princeton (U.S.) and Edinburgh in 1895, 1896, 1897. In her turn, she acted as hostess to the delegates of near and distant sister universities in 1900.

The University of Paris is at present again, what she was in her youth, the *rendezvous* of a host of students of every nationality. Over 1,200 foreigners are inscribed in her rolls: British, Hollanders, Belgians, Germans, Russians, Roumanians, Swiss, Americans, etc. Of the huge current of Americans and Japanese students that has been passing for years through the universities of Germany, a broad section has of late been diverted to Paris, the city of light, "la ville lumière."

Although the new or rather the rejuvenated university of Paris feels most keenly, that she is the legitimate offspring of the old one, and that, accordingly, the roots of her genealogical tree strike down to the 13th century, she has never indulged in any foolish pride of pedigree or nobility, and does not vouchsafe any of those artificial imitations of archaic forms of university life, which are traditional almost everywhere outside France. The Council of the new University has volunteered to publish the *Cartulaire,* the charter of the old one (strange enough this delicate work has had to be entrusted to an Austrian Dominican, resident in Rome, as the most competent man to take this publication in hand). As for the obsolete customs, the old names, the anachromistic costumes, they have not been reinstated in their former honour. It has not even been attempted to introduce anything like the distinctive colours and badges, so dear to the English colleges, to the Dutch, the Swedish and German universities. For a short while indeed, a few velvet caps and scarfs, showing the colours of the *facultés,* were conspicuous in the Quartier latin and its surroundings; but as these ornaments came to be largely sported by philandering counter-jumpers and office clerks, ne

student wore them any more, and they are hardly ever seen at present. The student of the French university dresses like everybody else and wears no gown, nor any insignia. There exists, it is true, an *Association générale des étudiants,* but it seems that this society devotes itself almost entirely to the economic interests of its members. At any rate it is little heard of. There and no professional masquerades either, no university pageants, no speeches and harangues in Latin or in Greek, no romantic and mediæval ceremonies, the fresh breeze of modernism, which is constantly sweeping Paris, has blown away all these ancient customs, which, in England, for instance, are being preserved with so much piety and in such striking accordance with the "*nolumus leges Angliae mutari.*"

The University of Paris, which is the youngest and at the same time the oldest of the great universities, has also this peculiarity, that her manners and customs show in every respect the character of modern simplicity. Nowhere indeed have university manners attained a higher degree of correctness and dignity than they have at Paris.

Summing up, and leaving all external features for what they are worth, we are coming to the main point: the spirit which animates at present the entire University of Paris. It is emphatically, what the reformers wished it to be at the outset of the reorganization, a purely scientific spirit. It is impossible to speak here, even in outlines, of the enormous amount of work done in these 25 years in her laboratories, hospitals and lecture-rooms, or to mention all the energetic research work that has been accomplished there along with the applications that have accrued from it, or to enumerate all the errors that have been discovered and rectified; in short to give any adequate idea of the whole of the productive progress and evolution of theories and ideas. Neither is it desirable, nor is it necessary, to compare the Paris University in these respects with others. In our days all the universities in the world are working fraternally and in close alliance at the accomplishment of one immense, collective task, in which each of them individually has only a limited share. The main and essential thing is to have a share in it, a share proportionate and consistent with our resources and powers as to staffs and finance. As far as this goes, nobody will contest the fact, that in proportion with her resources, the University of Paris has done exceedingly well on behalf of science. None of the *facultés* has given up the work of professional training; of course such a thing could not be done; but alongside of the State examinations—the syllabuses of which have been carefully revised—real university degrees have been established, which are obtainable only and exclusively on the strength of successfully accomplished, scientific work. The great principle of the reform of higher education, such as a few select minds conceived it in 1880, is now unanimously admitted and fully understood by the masters of this renovated branch of education.

All the *rapporteurs* uniformly repeat, almost year after year, what one of them, M. Croiset, doyen of the *faculté des lettres,* worded so admirably, when in 1896 he said:—

"L'ennemi que nous avons à combattre, c'est le souci exclusif de la préparation professionnelle. Le but à atteindre, c'est de fortifier sans cesse dans l'homme, *d'une profession l'esprit scientifique*. Les Facultés n'ont pas cessé de lutter depuis dix ans pour arriver à ce résultat."

We may say now, that they are fairly on the high road to success; for the consequences of this high-minded struggle have already considerably developed and are still developing in a normal manner. There is nothing that could make us in the least afraid, but this evolution should come to an unwished-for stop. Attempts at the spread and advancement of science are being made, which deserve universal attention and imitation. Since 1898 prominent members of the teaching staff have been delivering certain courses of lectures, which they call "*conférences de vulgarisation*," to collective audiences of students belonging to all the *facultés*. In 1899, after twelve of these lectures, the *rapporteur* to the University Council could write down: "The students have flocked in large numbers (over 800) to these lectures; and by their regular attendance, rather than by their cordial applause, they have shown their gratitude to the lecturers, who so gladly volunteered to undertake this increase of work for the pleasure and instruction of their keen and youthful audience who manifested such genuine desire after ideas and knowledge."

Besides, ever since 1898 masters and students have taken a most active part in delivering and popularizing university extension lectures. All, to a man, spare no effort to fulfil their noble task and conscientiously act up to the admirable principle, laid down by Emile Boutroux, the famous professor of history :—

"La tâche de l'éducation intellectuelle est de former l'esprit, tout en le munissant des idées et connaisance générales, qui président à la vie et aux sciences."

A powerful plea in favour of the training of the intellect, which is at the basis of all university work. Indeed, these words must sound like gospel in the ears of all that devote themselves to such work.

But I must not tax your kind patience any further. To conclude, I would ask only this question : Is there, amid all the good things which it has been my privilege here to point out, amid all that has been done and undone these 35 years, nothing that is open to improvement or that is to be regretted? Nothing indeed of vast importance. However, it was an act of gratuitous vandalism, eternally to be deplored, that the old Sorbonne of the 17th century should have been demolished, that grand, old quadrangle so remarkably pure in its lines, so eminently noble in its proportions, that historic pile, which from a point of view of pure art was superior even to the picturesque and venerable university and college buildings of Oxford and Cambridge, monuments and relics, which the English people maintain in such beautiful state of repair, and for which they show such fostering care. such striking piety. Indeed, nothing would have been easier than to appropriate the interior to the general wants and services of the University and of the *faculté* of letters, without either defacing or even altering the exterior in the least. The *faculté* of sciences could have been housed, as was originally planned, in a vast com-

plex of separate buildings, where it would have been at liberty to develop and expand according to its wants. Surely, the sumptuous new Sorbonne of to-day, which in spite of its huge dimensions is infallibly bound to prove too small a few years hence, will be burdened with a galling reproach that shall never be silenced : the murder of the Sorbonne of Richelieu. Then, again, there are no longer any sound reasons why the *Ecole normale supérieure* and the *Ecole des hautes études* should not be considered to be *collèges* or institutions of the University of Paris. These schools and the *facultés* of letters and of sciences have, to a large extent, the same staff of masters and the same students; the same spirit is henceforth to reign supreme in the establishments, which are part of the "corps universitaire" and in those which are not. So, if it is easy enough to see the advantages of eventual union, one wonders, what its inconveniences could possibly be. But what do these slight blemishes signify, in comparison with so vast a number of unquestionable boons and benefits? And will not the criticisms lose their *raison d'être* and die out as years go by, whereas the benefits will prove permanent and lasting? Really, the methodical creation of its universities will for ever and ever remain one of the most sterling claims which the governments of the third Republic possess, to the universal gratitude of the nation.

L'essentiel dans l'éducation, ce n'est pas la doctrine enseignée, c'est *l'éveil.*†

BUPHANE DISTICHA.—This poisonous bulb, whose physiological action and chemical properties were preliminarily investigated by Muller in the Grahamstown Laboratory in 1903 (*Rep. Senior Analyst C.G.H.*, 1903, pp. 63-65) has recently been exhaustively examined by Tutin in the Wellcome Research Laboratories, and an account of the investigation appears in the June issue of the *Journal of the Chemical Society* (pp. 1240-1248). Tutin confirms Muller's finding that the bulb contains a non-crystallisable alkaloid, and proposes to name it Buphanin. Muller found the physiological action of the plant to be that of a convulsant coupled with a secondary tendency to bring about respiratory failure. This too is now confirmed, the twofold action being ascribed to the presence of at least two distinct alkaloids. One of these has been identified as narcissine, the alkaloid of the daffodil. The amorphous buphanine is changed, by heating with alcoholic potassium hydroxide, into a crystalline base, for which the name buphanitine is suggested. During the course of the investigation acetovanillone, previously discovered only in *Apocynum cannabinum* and *A. androsaemifolium,* was found to be contained in the bulb. The plant, which is indigenous to South Africa, is well known in the Eastern Districts of the Cape Province, where deaths have frequently been caused by it, as "gift bol," and is one amongst many indigenous plants on which investigations had been commenced in the laboratories at Grahamstown without opportunity being found for carrying such investigations to finality.

†Renax: "Souvenirs d'enfance et de jeunesse."

THE INFLUENCE OF THE DARWINIAN THEORY ON ETHICS, WITH SPECIAL REFERENCE TO THE ETHICAL CONDITIONS OF THE STRUGGLE FOR EXISTENCE.

By Rev. Ramsden Balmforth.

I.

Seldom has a greater change taken place in the world of thought than that carried by the almost universal acceptance of the Darwinian theory of evolution. The change, which might be called revolutionary, has been compared to that caused by the substitution of the Copernican for the Ptolemaic theory in astronomy. In every department of scientific activity the evolution theory may now be said to have become the governing conception of thought. It is true there are important points in the theory on which men of science still differ, but their differences are differences about the method, not about the fact of evolution itself. We think and speak in terms of evolution, and the theory has so far permeated all our thinking that not only biological science, but ethics, economics, social and political theories and institutions are beginning to feel the influence of the new ideals and methods of thought which the theory has brought with it. An overwhelming accumulation of facts, drawn from nature and history, has broken down old conceptions of things, and has compelled us to adopt new conceptions and adapt our mental and spiritual outlook to the new methods of knowledge. It is the object of this paper to emphasise the influence of this great change of thought in so far as it has affected, or is likely to affect, our ethical relationships and outlook.

Fifty years ago, when Darwin's "Origin of Species" was first published, a feeling of indignation and despair passed through certain circles of thought. Many minds were filled with indignation at the thought that the ground was completely cut from under many ancient and cherished theories. Others were in despair in that the very foundations of both religion and ethics seemed to be quaking under their feet. Looking back upon the stormy controversies which followed the publication of that remarkable book, one may well wonder both at the horror-stricken anathemas of theological extremists and the pessimistic forebodings of more thoughtful and charitable minds. We can see now the clear gain which has come to humanity, and how the whole field of ethical study has been enriched by the vast mass of knowledge which Darwin and his fellow-labourers and successors have brought to our minds. Ethical advance has become clearer and surer. Science, which is organised knowledge, has shown itself once more to be the willing servant and helper of humanity. It has shown, quietly, unobtrusively, and even unintentionally, that where any speculative system or theory is founded upon error that system or theory is doomed to decay, and deserves its doom.

Much, indeed, of what was thought to be indissolubly bound up with the most cherished convictions of men has, during the past fifty years, gone by the board. The ancient story of the

fall of man is now either allegorised, or has given place to the more scientific theory of the gradual ascent of man—with important consequences to ethical science. In the light of this wider truth our attitude towards sin and moral evil, and our treatment of them, have undergone great modification. The theory of religious exclusiveness also has had to give way before the study of the religious history of mankind and the wider revelations of truth which comparative religion, the progress of science, and the evolution of the human mind have brought to view, with the result that our ethical relationship and duties towards so-called heathen races have undergone considerable modification.

On the other hand, there have been great positive gains. The spiritual and idealistic view of life, so far from quaking under our feet through the discoveries of science, has been based on stronger foundations than ever. One can hardly realise now the despairing state of mind which fifty years ago regarded materialism as triumphant, and looked upon the universe as summed up in the words, "Evolution" and "Law." The old mysteries remain. We are as far as ever from knowing the constitution of the atom, or from fathoming the mystery of the Energy which binds its elements together. As ever, we stand in the midst of "an Infinite and Eternal energy from which all things proceed." That is the mystery of philosophy, of ethics, and of religion. He would be a bold man who would say that the theory of evolution has solved that mystery or has plucked out its heart. The theory of evolution, valuable as it is, is helpless here. It knows only a succession of phenomena. It simply brings together the objective facts of life, and leaves them unrelated to each other by any binding principle of moral intelligence. Idealism furnishes that binding principle. Here, then, is where the spiritual view of life gains its standing-ground, and it is ground which is firm as a rock. Let us see what it builds on this foundation.

Evolution, I have said, gives us a mere succession of phenomena. Ethics and philosophy examine these phenomena, and try to appraise their value. They see that the facts or phenomena which science and evolution present to the intelligence of man are facts which not only have a varying value, but which, in the changes which they manifest, betoken a definite principle and purpose at work—a purpose which seems to demand that progress shall proceed from the simple to the complex, that is, from the physical to the psychical and the ethical. These changes are obviously the result of an interpenetrating spirit or principle of life which manifests order, intelligence and will, for without intelligence there would be no progress. It is idle to assert, as some evolutionists have done, that these increments of spiritual power, rising from the simplest cell to man, have accrued, as it were, out of nothing, or merely as a result of the interplay of blind forces. Out of nothing, nothing can come. The meaning of the universe, or such meaning as we can discern here, must be read, not in the dim beginnings of life, but in its potencies, as manifested in its most highly evolved types. To say that the slowly-evolving increments of consciousness are so infinitesimal that they do not count is to shut one's eyes to the

problem. The "Infinite and Eternal Energy" must at least be equal to its highest product. Dr. Edward Cairo puts this point very clearly when he says:

"It lies in the very nature of the case that the earliest form of that which lives and develops is the least adequate to its nature, and, therefore, that from which we can get the least distinct clue to the inner principle of that nature. Hence, to trace a living being back to its beginning, and to explain what follows by such beginning, would be simply to omit almost all that characterises it, and then to suppose that in what remains we have the secret of its existence. That is not really to expla in it, but to explain it away; for on this method, we necessarily reduce the features that distinguish it to a *minimum*, and, when we have done so, the remainder may well seem to be itself reducible to something in which the principle in question does not manifest itself at all. If we carry the animal back to protoplasm, it may readily seem possible to explain it as a chemical compound. And, in like manner, by the same minimizing process, we may seem to succeed in reducing consciousness and self-consciousness in its simplest form to sensation, and sensation in its simplest form to something not essentially different from the nutritive life of plants. The fallacy of the *sorites* may thus be used to conceal all *qualitative* changes under the guise of quantitative addition or diminution, and to bridge over all difference by the idea of gradual transition. For, as the old school of etymologists showed, if we are at liberty to interpose as many connecting links as we please, it becomes easy to imagine that things the most heterogeneous should spring out of each other. While, however, the hypothesis of gradual change—change proceeding by infinitesimal stages which melt into each other so that the eye cannot detect where one begins and the other ends—makes such a transition easier for the *imagination*, it does nothing to diminish the difficulty or the wonder of it for thought.*

The product of the universe, then, being psychical or ethical, the substratum must surely be psychical or ethical in its nature and purpose. Here we are on the heels of the ancient controversy between ethics and metaphysics—a controversy into which I do not propose to enter. I cannot agree with those who say that we must first arrive at some conclusion with regard to the Ultimate Reality of things before we can frame any consistent ethical theory. Our Knowledge of that Ultimate Reality is necessarily fragmentary, partial, inadequate, and therefore provisional, and subject to revision in the light of wider knowledge. Indeed, I think it would be easy to show from history that men's conclusions in regard to that Ultimate Reality have frequently stood in the way of ethical advance, and have led to conduct which we now condemn as unethical. Life is a warfare. Every waking moment has its ethical constraints and behests, and the result or outcome of these enters into our estimate of the nature of Reality. I have my own view as to the nature of the Ultimate Reality, but I should not care to say that this particular view is necessary to any fruitful or consistent ethical theory for another man. We must be prepared to recognise temperamental differences in this matter, for our outlook upon the universe is determined largely by our temperament, that is by our hereditary mental endowment. It will be sufficient for my purpose here if I indicate my standpoint, which, briefly, is this—that inherent in every form of life, however lowly, there is a desire, a craving, a love, for something higher than self. This some-

* The Evolution of Religion, Vol. I., pp. 49-50.

thing in man we may call his moral and affectional nature. Readers of Spencer, Darwin, Wallace, and Drummond will remember that magnificent poem of evolution which science has presented to us in the gradual unfolding of this, the highest attribute of Life. Out of the deeps it comes, yet it must first have been in the deeps ere it could arise from them. The "Infinite and Eternal energy from which all things proceed" must have a nature, a positive character—it cannot be signified or represented by a cipher. It is through evolution that we learn its significance, its character. Evolution gives us the facts, science arranges and classifies them, philosophy and ethics assign to them their value and help us to determine the aim of life accordingly. For Life is not a simple series of isolated states, a mere fragment of Nature, it is a complex something bound together by a pervasive intelligence and will which, as it expresses itself in our individual life, judges, condemns, and approves in accordance with a higher realm of ideas, which look down upon that sense-life which is the channel or the instrument through which evolution, in its higher aspects, works. Hence, the fact that man is not a mere fragment of Nature, but stands, in his spiritual essence, as it were, apart from and above Nature, and, while partaking of her life, questions, judges, uses, and at times despairingly condemns her—this fact, I say, lifts him out of the realm of mere physical cosmic processes, and leagues the highest part of him—his personality—with something which is infinite and eternal. It is here that the theory of evolution has so deeply influenced the development of philosophic, ethical and religious thought. So far from getting rid of the old mysteries, it has brought them back in new and more deeply spiritual guise to stimulate the eternal hunger of the soul. Hence the commanding place which the Science of Ethics occupies in our life and thought, claiming the right to be heard on these supreme questions of life, *e.g.* the form or standard of moral judgment, the aim of life, the value of life to the individual soul, and the relation of the individual soul to the whole.

II.

If we pass from a consideration of evolution in general to the methods by which it works and the results which it brings about, we shall see at once how closely bound up its processes are with ethical considerations, and how deeply the theory has influenced modern ethical speculations. Here, again, the whirligig of time has brought about a very definite change in opinion as to what evolution and the struggle for existence implies. It was at one time thought by many that that struggle, with its concomitant of the survival of the fittest, meant a blind warfare between different species, or between individual members of the same species, a warfare determined mainly by brute strength or cunning, and unconditioned by moral forces, ends, or aims. This interpretation of the theory seemed to fix itself in the public mind for a time, and "Nature, red in tooth and claw," came to be regarded as a great force dominating and controlling evolution. But a deeper consideration of the theory soon brought new, or rather neglected,

factors into the foreground. It soon became obvious that the interpretation of the word "fittest" must depend on the conditions to which life has to adapt itself. As I have elsewhere pointed out—

"in a community of foxes the most cunning fox would survive; in a pack of wolves the wiliest and strongest wolf; while in a community of ants, those which had the least power of intelligent co-operation would be the first to become extinct. And it is equally obvious that the interpretation of the word "selection" must vary in every grade of life, with every rise in intelligence—intelligence being, in normal circumstances, the prime factor which determines selection. Our garden roses would soon degenerate were not the selective intelligence of the gardener brought into play. Hence, intelligence, whether self-determining or brought into play from without, is obviously one of the conditions which determine fitness. But there are even higher determining conditions than intelligence, for intelligence alone may manifest itself in mere cunning. The qualities of prudence, temperance, fidelity, sympathy, co-operation, self-sacrifice for a common good—all these are amongst the determining conditions of fitness, for a people that has these qualities will always be able to hold its own against an imprudent, intemperate, unfaithful, unsympathetic, and selfish people. As Darwin himself says: 'A tribe rich in moral qualities would spread and be victorious over other tribes, and thus the social and moral qualities would tend slowly to advance and be diffused throughout the world because they were the fittest to survive.'"*

All this is now commonplace to the thoughtful evolutionist, but it is necessary to emphasise it occasionally, for I submit that this consideration throws great light, not only on the methods of evolution, but on the nature of the spritual forces which are working in and through evolution. I am not one of those who shut their eyes to the darker sides of nature, or who, burying their heads, ostrich-like, in the sand of what Viscount Morley calls a "complacent religiosity," pretend that everything is for the best in the best of possible worlds. The evils which surround us, many of which seem to be bound up with life itself as we know it, are too palpable to be ignored or minimised by any clear-sighted or right-thinking mind. But, on the other hand, this upward life-tendency, which is everywhere observable in nature, cannot be ignored either. If it does not give us all the light we desire, it gives us enough to show the way we ought to go. For if nature's way is, in the long run,upward, then our way is upward, too, and the lower reaches of nature, in so far as they seem to contradict or militate against this upward tendency, are to be avoided, not imitated, by us. "But we have sprung from those lower reaches!" So we have. But because the darkness of the night gradually and by imperceptible degrees gives place to its apparent opposite, the light of day, that is no reason why we should deny the light or try to adapt our sight and life to conditions of darkness. Professor Huxley's dictum, that the cosmic process is at issue with the ethical process, is only half the truth, even if that, for the cosmic process *includes* the ethical process, and, on the higher planes of life, both are often at one. The struggle for existence, even in the lower reaches of life, implies the observance of certain ele-

*See article on "Darwinism and Empire," *Westminster Review*, July, 1902.

mentary rules of conduct, non-observance of which may bring death to the individual and extinction to the species or race. The teaching is clear. Natural selection means, for us, not merely the selection of the fittest in any given surroundings, it means the fittest and the best in the fittest and the best surroundings which are likely to aid in the development of ever more perfect, or less imperfect, types of life. Nature's command is—grow more intelligent, more justly sympathetic, more moral—or, perish.

Neither must it be thought that we are mere *products* of evolution. Such a conception would strike at the root of ethics and would leave us to watch, with folded hands, for whatever the blind gods of Fate might send. We are factors in, and not merely products of evolution, and our moral ideals and judgments help to determine the process. Hence, the production of such an environment, and it is the chief business of the parent, the teacher, the and highest types of life should be the first business of the philosopher, the teacher, the legislator, the parent, the minister. It is the business of ethics to discover the conditions of such an environment, and it is the chief business of the parent, the teacher, the sociologist, and the legislator to arrange the affairs of the home, the school, society, and the State in such a way as will conduce to its realisation. In doing this several considerations naturally present themselves :—

(1) If natural selection is to have fair play, to what extent should the laws of inheritance and the customs which determine the distribution of the "unearned increment" be modified in order that all may have a fair start in the battle of life, and freedom of opportunity be given to everyone to develop the best that is within him.

(2) To what extent will the forces underlying natural selection be modified by this freer, healthier and juster environment.

(3) Will natural selection be ultimately superseded by what is termed "artificial" or intelligent selection. (It follows, of course, from what I have said above, that artificial selection is really a part of the natural, using the latter word in its widest sense.)

(4) To what extent will racial developments, racial antipathies, and racial strife and competition be affected by the struggle for existence and the methods of artificial or intelligent selection to which it may give rise.

I can deal with these four considerations in only a very brief and inadequate way as suggesting matter for discussion rather than as laying down definite conclusions.

(1) Few people now-a-days will contend that there is much regard for morality or ethics in our present laws of inheritance. Long ago Matthew Arnod pointed out that no civilisation could endure for long which was based on such laws. That a millionaire or a multi-millionaire whose wealth has been made bv very questionable means should be allowed to tie up and bequeath this immense stock of socially-produced wealth to whomsoever he

pleases, without any consideration for the welfare of the society which has enabled him to accumulate his wealth, is one of those customs which, as a result of modern ethical developments, is already undergoing considerable modification. When his accumulations consist of what is really unearned increment the injustice becomes more glaring; and when those to whom he bequeaths his gains are obviously unfitted to use the enormous powers which great wealth places in their hands, the evil effects upon society are still more patent. It is artificial selection carried to an absurd and pernicious extreme, often giving undue advantages to the least desirable types of character. The millionaire is rapidly coming to be regarded not only as a social, but also as a moral, monstrosity. One of the more enlightened ones has already enunciated the doctrine that no man should die rich. The new ethics, in the interest of the general good, will insist that no man should live unduly rich. It will emphasise the fact that robbery by the individual from the community is as immoral as robbery by the individual from other individuals. And it will point out that such robbery produces depraved and undesirable types in three directions—types which become ethically diseased or depraved by the excessive luxury and power which inordinate wealth gives; other types which become parasitic on the former, and which help to spread throughout the community a truly loathsome spirit of subservience and servility; and a third type, which is deprived sometimes of the very necessaries of physical health, and often of the opportunity for intellectual and artistic development by the unjust usurpations of the two first-named. To use an expressive phrase of Mr. Ruskin's—just as modern industrial developments exterminated the "crag-barons" of feudalism, so the higher social conscience developed by evolutionary ethics will, in time, exterminate the "bag-barons" of modern commerce and finance. As a means towards a more intelligent natural selection and survival of the most desirable types, it will urge that all unearned increment, whether of land or other forms of wealth, should be handed over to the State and used for the general good, more particularly in the endowment of childhood and the various forms of education, so that the younger members of the community may enter the struggle for existence on fair terms. As Mr. Francis Galton points out:—

> "The best form of civilisation in respect to the improvement of the race, would be one in which society was not costly; where incomes were chiefly derived from professional sources, and not much through inheritance, where every lad had a chance of showing his abilities, and, if highly gifted, was enabled to achieve a first-class education and entrance into professional life, by the liberal help of the exhibitions and scholarships which he had gained in his early youth."

It would take me too far afield to attempt to forecast or discuss the great changes which such a policy would bring in the evolution of new industrial, æsthetic, and moral types. It is sufficient to say that progress has two roots—the economic and the spiritual—the latter including the intellectual, æsthetical, and moral relationships of men, each having its separate growths or causal series, and it is by the reciprocal action of the two that human evolution, or moral and social progress, is made not only possible, but, I think I may say, inevitable. In any case, it is obvious that just as the evolution

of ethical ideas affects social customs and institutions, so will the modification of social customs and institutions affect evolution and selection, and therefore the types of character which evolution produces.

(2) To what extent will the principles underlying natural selection be modified by this superior environment? It is difficult and perhaps idle to attempt to forecast the types of character which this so-called artificial selection will tend to produce. Much will depend upon the ideals which mankind may have formed and which the State may strive to realise. In a society dominated by the ideals of science the scientific character and the scientific type will be fostered. Already our educational institutions and our educational policy are being influenced, though perhaps not yet consciously influenced, by such ideals. There is not the least doubt that, in the long run, the forces which make for a superior kind of so-called artificial selection will begin to tell—indirectly, I mean. Every extra pound taken from unearned increment which is at present spent on "freak" dinners, and devoted instead to public education, is so much wealth and energy devoted to foster one type of character as against a lower and baser type. What form, in every given case, public education should take, what amount of money should be devoted to it, what particular aptitudes should be stimulated, what traits developed, what opportunities given to the superior types, and what measures should be taken for the surveillance, or even the suppression of such methods of industry and life as tend to injure or undermine the health of the individual, and through the individual, the race;—all these are questions which are full of interest to the student of ethics, questions the solution of which will have a very direct influence on the working of the principle of natural selection. The chief point, however, which I wish to emphasise is this—that evolution, so far from promoting the survival of that individualistic type of morality which the phrase "the survival of the fittest," seems to some people to imply, promotes and strengthens rather the survival of those forms of life which embody the social ideal of morality. The personally upright man cannot survive, or finds it difficult to survive, in a society in which personal rectitude is of no account. Galton, I think it was, pointed out long ago how severely the best types of life suffered during the persecuting spirit of the later middle ages. The very phrase "personal holiness" cannot be adequately defined apart from a complementary conception of civic virtue, and civic virtue, as we shall see, is necessitated by evolution if the best types of life are to survive.

(3) Closely connected with the above considerations is the question as to whether the methods of artificial selection will be carried so far as to take the place of natural selection. It is sometimes urged that the tendency of modern civilisation, especially where it is animated by Christian ideals, is to preserve rather than to eliminate the unfit, and that the multiplication of charities, hospitals and philanthropic institutions tends to produce and prolong the existence of a weak, nerveless, and decadent population. The only way to avoid this, it is said, is to carry artificial selection to such an extent as to segregate or otherwise deal with the morally depraved

or the physically inferior or infected types, and allow only the fit type to propagate their species. Sympathy, it is said, may be carried too far, so far, that the multitude on whom it is expended may become a drag and an encumbrance on the nation which has to bear the added burden imposed by the presence in society of a relatively large number of weaklings and incapables who are allowed to propagate as they please. We are told by Mr. Sidney Webb that the average number of offspring amongst English intellectuals is only 1.5. In the criminal, depraved and imbecile classes it ranges between 6 and 7 per family. Leaving the moral point on one side for a moment, it may be pointed out that the policy of segregation is already carried out to a certain extent. We segregate imbeciles, lunatics and criminals. To what extent the same policy should be adopted with regard to chronic physical and hereditary diseases is a matter of opinion, and opinion is strongly growing in this direction. Whether public opinion on this matter should crystallise into law is a question which I cannot now stop to discuss. But I may point out on the other side that society has not yet taken sufficiently active steps in the direction of eliminating disease bv sanitation; the provision of healthy environment and healthy conditions of labour; education, physical, mental, and moral; and the provision of means of pure and cleanly living, to justify it in going far in the direction of a policy for the compulsory segregation of the physically unfit. As showing what may be accomplished by a purer and healthier environment, Pro. Henry Jones points out that the Poor Law Inspector of Glasgow sends every year into the country districts of Scotland numbers of little children found in the streets, "picked up selling newspapers between the knees of drunkards in public-houses." These children are "born invariably of the worst parents," but on being placed in proper homes and good surroundings, they usually turn out all right. They are kept under close observation for years, and out of 630 children so sent out and brought up only 23 turned out badly—"A smaller proportion," the Inspector playfully added, "than if they had been the sons of ministers or professors."

We must also bear in mind that many persons who might by some have been regarded as mentally and physicallv unfit—the Apostle Paul, for example—were men who reached the topmost heights of personality. Genius is often near allied to madness. We must remember also that the policy of segregation (and the more drastic policy advocated by some eugenists, if carried too far, though it might appear to promise obvious and immediate advantages would have less obvious but none the less certain and serious dangers which would more than neutralise any advantages it might bring. The moment we begin to tamper with the roots of human sympathy that moment are we on a dangerous incline which might lead us to a worse than Pagan cruelty, selfishness and slavery. We might find that the discouragement of the growth of human sympathy, leading to the segregation or the extinction of our unfortunate fellow-creatures, might so affect our civilisation that its very root and basis would begin to canker and decay. And here let me say that I am not one of those who look upon charity, as it is usually understood, as one of the highest of virtues. There

is a morbid, unhealthy spirit abroad which seems to take the view that self-sacrifice, as self-sacrifice, is a good thing in itself, and that it is necessary that we should have a certain number of unfortunate members of society—the halt, the maimed, the blind, the imbecile—for the purpose of stimulating the sympathetic virtues of charity and self-sacrifice in our fellows. Such a view of life seems to me to be morbid and unhealthy. It is " more life and fuller that we want," the mission of the greatest of teachers was well said to have been to give life and "to give it abundantly." By all means let us have the superman, if we can get him without the loss of those qualities which have brought human nature to its present level from savage and barbarous beginnings. A healthy public opinion will do much towards creating, fostering, and deepening that sense of responsibility which should be felt by all who take upon themselves the duties of parenthood. How far we should go in enforcing the prior conditions of parenthood which that sense of responsibility should teach us to secure, is a question much too large for discussion in this paper, but there is no doubt that the evolutionary ethics of the future will give the question serious consideration. Already, indeed, we may all describe ourselves as modern eugenists when the health and welfare of our own descendants are concerned.

(4) The fourth question suggested by a consideration of the problems surrounding the survival of the fittest and the best, *i.e.*, the extent to which racial developments and antipathies will be affected by the struggle for existence and by methods of artificial or intelligent selection is one which may well appal the stoutest heart and mind when we think of the many and grave issues which are involved. A great conflict of races, the East with the West, for example, is not by any means an improbable event, when we consider the result of the late war between Russia and Japan, and the racial developments which are so rapidly making their influence felt in the economic and industrial world, especially in the United States, Canada and Australia, not to mention South Africa. There are some who speak of these racial antagonisms in a light and airy way, and say, "Let the conflict between East and West come, the law of the survival of the fittest must prevail there as in other spheres of life." Such people do not know the strength of the forces and passions of which they speak so lightly, neither do they sufficiently consider whether a racial war would really decide all the issues or even the chief issues involved. It is too often forgotten that, as far as the survival of races is concerned, a war decides little or nothing. Even a conquered race may be so prolific, or may so use its natural capacities, advantages, and power of adaptability to varying conditions as to modify the characteristics of a temporarily conquering race, or even to absorb such a conquering race altogether, as the Anglo-Saxons absorbed the Normans. It is said, for example, that when Chinese or Japanese intermarry with Europeans the Eastern type tends to persist as against the European. It cannot be too strongly insisted upon that on this point war settles nothing; while the notion of holding some five hundred millions of Eastern people permanently in subjection—even if they could be conquered—is surely too wild even for the

wildest Jingo to entertain. As Mr. Bagehot, in his "Physics and Politics," points out in a very pregnant sentence—

"Military morals can direct the axe to cut down the tree, but it knows nothing of the quiet force by which the forest grows."

Hence, the moment the period of conflict is over all the other more permanent and persistent determining conditions of struggle and progress come into play.

What, then, is the teaching of evolutionary ethics in this matter? It is surely to pay more attention to these determining conditions of survival, and to do all in our power, by conference, by conciliation, by education, by respect for national rights and national religions, and by international deputations and congresses, to bring the best thought of each civilisation into sympathetic contact with that of the other, and so promote the establishment of that "paramount authority of right reason" which will make for the development of a sense of world-citizenship and the constitutional machinery by which it may be fostered. As Darwin himself said:

"As man advances in civilisation, and small tribes are united into larger communities, the simplest reason would tell each individual that he ought to extend his social instincts and sympathies to all members of the same nation, though personally unknown to him. This point being once reached, there is only an artificial barrier to prevent his sympathies extending to men of all nations and races."

Already a beginning has been made in this direction. Next year a Universal Races Congress will meet in London for the purposes of discussing racial, national, political, sociological, economic, and commercial questions in this spirit. And it is only by discussing our problems in this spirit that we can promote, directly within each nation itself, and indirectly, by the friendly rivalry of races and nations, the survival of the best types. Just as Dante had his dream of a world-empire from the point of view of the mediæval spiritually-minded Catholic, so the modern evolutionist may have his dream, not perhaps of a world-empire, but of a world-commonwealth, in which the penetrative power of ideas, and the freedom of the spirit in assimilating and propagating ideas shall triumph over the brute conditions of struggle which have hitherto been the determining conditions of survival. New types begin in the realm of consciousness, in the dim dawn of an ever-ascending consciousness, and it is to this ever-evolving and developing consciousness—with full opportunities given to it to manifest its life at its best—that we must look for the emergence of those higher types which this secret and mysterious realm holds within its illimitable domain.

It will be obvious, I think, from this paper, that the Darwinian theory of evolution has enriched the whole field of ethical study. It has brought new ethical problems to our notice, and has shown how intimately connected the science of ethics is with evolutionary thought. Whether our individual standpoint is naturalistic or spritualistic, we cannot but express our indebtedness to the labour of the evolutionists and join hands together in the work of endeavouring to solve the problems which this great upheaval of thought has brought more fully and clearly into the light of day. The cause of ethical progress is a platform on which all can meet.

HITTITES IN AFRICA.

By J. K. Erskine.

Among the many directions in which the increase of knowledge has brought about that widening of our outlook on the universe, which has been so marked a feature of the present age, there are few in which the results of research have been of more general interest than in those which have dissipated some of the obscurity which veiled the past. Year by year, the investigations of the archæologist are bringing to the light the history of nations, the memory of whose achievements had altogether passed away, whose very names had been forgotten.

In all parts of the world discoveries have been made which have contributed, or will yet contribute, to the elucidation of these problems relating to the past, and here also in South Africa, far removed although we are from the ancient centres of civilization, we have before us a wide field for investigation only partially explored, the results of the exploration of which, when rightly interpreted, cannot fail to add to our knowledge of the growth of civilization and the history of human progress.

Of the archæological and ethnological problems which confront us in this country, one of the most important perhaps is that which relates to the identification of the races who are responsible for the ancient workings and ruins of Rhodesia. In venturing to discuss this matter, and to suggest anything in addition to the theories which have already been brought forward on the subject, I feel that I may well be held guilty of presumption, more especially as I can make no claim to speak as an expert on the subject and can bring forward no new facts, where there would seem to be more need of facts, than theories. I can only endeavour to put forward the impression made on my mind, by such of the available evidence as has come to my notice.

The first point perhaps, which strikes one on entering upon any consideration of the subejct of these ancient workings and ruins, is their extraordinary number and the great stretch of country over which they are found. Mr. R. N. Hall speaks of over 500 distinct sets of ruins, and almost everyone who has travelled to any extent in Rhodesia, and even many whose travels have not been extensive, but who are well acquainted with some limited area, can tell of ancient workings and ruins of which no record has hitherto been made. A great part of Southern Rhodesia, in fact, is riddled with the mines of the gold seekers of bygone days and is strewn with the ruins of their towns and fortresses. In the Transvaal also, as is well known are many old workings; many of these may be of comparatively modern origin, but there are some which may on investigation prove to be of great antiquity; particularly interesting on account of the obscurity which surrounds the question of the supply of tin in the ancient world, are the old workings for tin in the Rooiberg, which extend over a line of about five miles.

A consideration of the number and extent of these ancient workings makes it evident that the total gold production of Rhodesia, from first to last, has been very great, and although any estimate of what this quantity has been can only be the roughest of approximations, I feel convinced, from calculations of the tonnage mined in certain very limited areas, that any estimate which has been published is far more likely to be under than over the mark.

This conclusion (or assumption) concerning the magnitude of the gold production of Rhodesia in the past, must necessarily have some bearing on any attempt which may be made to determine the date at which the gold-bearing rock was mined. I find it difficult to believe, for instance, that so large an amount of gold can have been taken out of Rhodesia in mediæval times without some more definite record, than seems to exist, of its export being left, and even if no other record had remained, I should have expected so great an augmentation of the gold supply to have been more strongly reflected, than seems to be the case, on the economic conditions of the world of that time.

In view of what follows, it may here be noted that the augmentation of the world's gold supply, during the early centuries of the Christian era, seems to have been small. In the Roman Empire at any rate, the available supply of gold was constantly diminishing for many hundred years, if one may judge by the continued rise in its purchasing power, the frequent tampering with the currency and the succession of financial crises.

It is important to note, that the gold production of Rhodesia has not come to any great extent from alluvial workings, or from mere shallow holes in the surface, or in the sides of hills, but has been obtained by systematic mining carried on by experienced miners, skilled according to the skill of their times, miners who understood the sinking of shafts, the driving of adits, the breaking of rock and the following up, not only of the gold-bearing veins, but also of the more profitable sections of these veins.

There has sometimes been a tendency, I think, to underestimate the skill and experience which must have been possessed by these ancient miners, and to overlook the importance of this point as a clue to their identification. There is no need to labour the point; but as a matter of fact, the trifling and often useless results which can be achieved in mining by inexperienced men, with a great output of energy, is almost incredible, the following up of gold-bearing veins also, and of the more profitable sections of these veins is by no means at all times a simple matter, but is a matter which requires constant care and watchfulness, the facility with which the reef can be lost, the tendency to follow up some unprofitable vein or some cleavage in the rock by mistake, and the constantly recurring difficulties which arise from disturbances in the formation, have to be experienced to be understood. At the present time, there are doubtless many profitable claims which lie abandoned owing to the inexperience of those who worked them. Even on the Rand, as those who make a study of mining reports may have noticed, it has not been an unknown experience for stretches of profitable rock to have been

left by accident on the foot or hanging wall, as the case may be, and unprofitable rock taken out instead.

I have heard it claimed that skill in mining is inborn, and cannot be acquired. Without going so far as this, I nevertheless think that the skill indicated by the ancient workings could not have been acquired by any people in a few years, or even in a generation, and I feel certain that if this mining is the work of a people of the same race as the existing native population of South Africa, that preceding the extensive mining operations that were evidently at one time carried on, there must have been a considerable period of development on the part of at least a section of the population, and that altogether there must have been a long period of persistent effort, which could not have failed to have had a profound effect on the character of these people, on their habits, their condition and on their capabilities; an effect which would not readily have passed away and would not have been effaced in a few generations. So far as we have any historical evidence, however, judging from what Portuguese and Arab writers have told us, at no time during the last thousand years do the natives of South-East Africa seem to have been essentially different from what they are to-day. I think it far more probable that the ancient mining in Rhodesia was the work of foreign intruders, who brought their experience with them from some other land, and who also brought with them a capacity for organisation and for persistent effort, which we do not generally find among the natives to-day, and which I do not think we should have found among their ancestors of a few hundred years ago.

Turning now to a consideration of the ruins of buildings in Rhodesia, we have before us as alternatives, on the one hand, the supposition that these buildings were the work of natives of the country and represent the outcome of a culture locally developed; or, on the other hand, that they were the work of foreigners, who brought with them to South Africa a certain culture and civilization from their original home. If the first supposition were correct, we should expect to find on the sites, of at least some of the ruins, evidences of previous occupation, and some indications of the origin and growth of the culture they represent; for it seems to me inconceivable, that natives who may, or may not, have been in the habit of building round huts of rough unhewn stone, should suddenly begin to erect walls of massive masonry, built of pressed stone, laid in regular courses, constructed on a complicated plan and showing evidence of astronomical observations. What appear, however, to be the oldest buildings would seem to be the best, and so far as I can learn, no evidence of any period of development preceding the building of these has hitherto been found. I find it difficult to believe that these mines and buildings were the work of the ancestors of the present native population in mediæval times, not so much perhaps because achievements such as these would be beyond the limits of their capabilities, as because they lie outside the line of their natural aptitudes and inclinations. As an analogous case, I have seen quoted that of the artistic development of negroid peoples in West Africa, under the stimulus of contact with the

Portuguese, as exemplified in the bronzes of Benin; but this analogy does not appeal to me, as it seems to me that development on the lines of decorative art such as these is what a knowledge of the negro might have led one to expect, as a possibility in the past, and may lead one to foresee, as a still greater probability in the future. However this may be, the evidence which has so far been brought forward in support of the view that the buildings in Rhodesia were the work of natives seems to me to be altogether too slight to support such a conclusion.

If on the other hand we turn to the possibility of these buildings being the work of foreign intruders into South Africa, we are not met on the threshold of our enquiry by any inherent improbability in such a supposition, and it seems advisable to consider who these intruders may have been, and at what time their intrusion took place.

The simplest method of attempting to solve these problems seems to me to be that of first seeing if any direct evidence can be found as to the time at which the ancient buildings in Rhodesia were erected. At the outset of our enquiry we have the fact that in some of the ruins trees are growing, which must have taken a long time, probably centuries, to attain their present growth; and we must also consider the possibility that a considerable time may have elapsed between the last occupation of the buildings and the beginning of the growth of the trees. We have next to consider that at the time of the earliest Portuguese visitors to the country, the buildings were even then considered very old, and this seems to have been the opinion of Portuguese, Arabs and natives alike. There is a strong presumption, therefore, that the period we are seeking cannot be found during the last eight or nine hundred years, and a consideration of the history of the world during the thousand years preceding this, renders it extremely improbable that any extensive mining could have been carried on in Rhodesia during that time, so that it would seem necessary to attribute to the ruins an age of at least 2,000 years; in fact argument on this line would carry the date back some centuries before the Christian era. But we have the possibility of a more definite clue of great importance in the orientation of several of the ancient buildings in Rhodesia. In these days, when, as the result of centuries of accurate observation, the length of the year is known to a fraction of a second, and the construction of the calendar presents no difficulty, we are liable to forget that this has not always been the case, and that to civilized peoples of an earlier day the correct determination of some definite date in the year was a matter of great importance and of some difficulty. It is probably for this reason that we find many ancient buildings (generally temples) constructed on an astronomical basis, sometimes for the observation of certain fixed stars, sometimes for the observation of the sun at the Equinoxes, but more generally for the observation of the rising or setting sun at the solstices. This orientation we find in the temples of Egypt and Greece, and even in such structures as Stonehenge and the stone circles of Brittany and other places, and if the ruins of Rhodesia are ancient, we should expect to find in them some

evidences of orientation, and as a matter of fact I think we do find it. The importance of orientation, of course, is due to the fact that the orientation of a building fixes its date in consequence of the changes brought about by the Precession of the Equinoxes and the secular diminution of the obliquity of the ecliptic, in the points where, at any particular place, the heavenly bodies appear to rise, culminate and set. When these considerations are applied to the ancient ruins in Rhodesia, we have been told that they indicate dates for the construction of these buildings which fall in the second millennium B.C., and it is interesting to note that at that time gold seems to have been comparatively plentiful in the ancient world. Of course, owing to the slowness of the change in the obliquity of the ecliptic, any date derived from a consideration of the rising or setting sun at the solstices (and it is on this that the orientation of the ruins in Rhodesia are generally based) can only be roughly approximate, but within certain definite limits the date obtained can be certainly relied on. With regard to the ruins in Rhodesia, an isolated case of orientation might be due to coincidence, in some cases there may be uncertainty as to the date obtained owing to uncertainty as to the point from which observations had been made, but owing to the number of cases of orientation noted, the evidence in its cumulative effect appears to me to be convincing.

These points which I have already touched on are only some of those which have impressed me, and there are many others which I will not have time to discuss; but these, and indeed those also of which I have spoken, have already been more ably dealt with by Mr. J. Theodore Bent, Mr. R. N. Hall and others, with whose conclusions, up to a certain point, I generally agree. There is, for instance, the interesting point of the preesnce in the neighbourhood of the ruins of plants not native to the country, and the important point of the distribution of the ruins throughout the country, and the question of the purpose for which each building may have been erected.

To summarize the conclusions which may be drawn from the evidence to be found in Rhodesia itself, it seems to me that we may fairly conclude that, about 3,000 to 4,000 years ago, Rhodesia was occupied by a people, possessed of a certain civilization, who came to the country for the purpose of exploiting its gold mines, and who brought with them miners experienced in mining mineral lodes. We find that these people built towns in suitable localities and erected lines of forts to protect their trade routes. It is evident also that they possessed some administrative ability and capacity for organization.

We now come to the question: Who were the civilized peoples of the second Millennium B.C., and from which of them could have come the ancient miners of Rhodesia. Only a little time ago we should have had to confess that the only civilized peoples of that time of whom we had any real knowledge were the peoples of Egypt and Babylonia, and in neither of these countries does it seem probable that we shall be able to find the original home of the ancient settlers in Rhodesia.

The consideration of Babylonia in this connection may be

almost immediately set aside, for the peoples of Babylonia of those days were not in the habit of making long sea voyages, and were evidently not in direct touch with any considerable source of gold supply. The case of Egypt, however, is more difficult. The Egyptians undoubtedly commanded a considerable and constant supply of gold. They were in the habit of sending trading expeditions to the land of Punt, which was somewhere to the south, and they obtained by means of these expeditions certain products, some of which certainly seem to have come from East Africa. It was suggested by Dr. Carl Peters that the land of Punt was in South-East Africa, but there are seemingly insuperable difficulties in the way of the adoption of this view, and I understand that Dr. Carl Peters has since abandoned it. As a matter of fact, I believe that the gold supply of Egypt was for the most part obtained from the mines of Nubia, the importance of which to the Egyptians is clearly shown by a study of Egyptian history. The amount of gold at the disposal of the Egyptians seems to have been closely connected with the effectiveness of their hold on Nubia at any particular time. The effective and continuous occupation also, for a long period of time of a country so far removed from Egypt as South-East Africa, seems extremely improbable, from all that we know of Egypt and Egyptian history.

Behind the history of Egypt and Babylonia, however, and the few fragments of the history of other peoples of these ancient times which have come down to us, recent research has shown us that there lies a vast stretch of history, which only a little time ago was undiscovered, and even now is to a great extent unexplored. We find that some 4,000 years ago Asia Minor, Syria and the islands and shores of the Mediterranean were inhabited by peoples who were the possessors of civilizations which had much in common. It is outside the scope of this paper to discuss the origin and growth of this civilization, even were I able to do so. In some cases, no doubt, it was spread by the migrations of nations at dates which can be approximately ascertained.* In other cases its origin must be sought in very remote times, and its growth took place to a great extent in the localities in which we find it. On the sites of the cities of the Hittites we find evidence of occupation going back to neolithic times, and indications of the growth of the culture which culminated at the time of the wide extension of the Hittite empire.

Of all these peoples the Hittites were perhaps the most enterprising and energetic, and they were in many respects the most important. They were the connecting link between the East and West, and supplied many of the elements of the ancient civilizations of Europe, from which our own is to a great extent derived; to quote Professor Sayce :—

"Among the great political forces of the ancient oriental world, we now know that none exercised a more profound influence than the Hittites of Asia Minor. It was they who overthrew the Amorite

*The Etruscans, for instance, had definite traditions of having come from Asia Minor.

dynasty of Babylon, to which the Amraphel of Genesis belonged, to them was due the fall of the Egyptian empire in Asia, and it was they who checked for centuries the desolating advance of the Assyrians. In Palestine their influence was supreme, and it is with good reason that in the tenth chapter of Genesis Heth is named second among the sons of Canaan. They were the founders of the Heraklid dynasty in Lydia, and Babylonian art, as modified in Asia Minor, was carried by them to the Greek seas. Greek religion and mythology owed much to them; even the Amazons of Greek legend prove to have been the warrior priestesses of the great Hittite goddess. Above all, it was the Hittites who controlled the mines of Asia Minor which supplied the ancient world with silver, copper, lead and perhaps also tin. Before the age of Abraham, traders carried the bronze of Asia Minor to Assyria and Palestine, and thus transformed the whole culture of Western Asia."

If we compare the ruins of Rhodesia and the objects found there, with the works of the early population of the shores of the Mediterranean and Asia Minor in general, and of the Hittites in particular, we find many striking points of resemblance. In both cases we find the same walls of massive construction built of blocks of stone laid in regular courses without mortar. (The walls of the aeropolis of the ancient capital of the Hittites in Cappadocia are 14 feet in thickness.) We find a choice of similar sites for the erection of fortresses, although this is probably of little importance and would naturally arise from considerations of defence; we find the same narrow entrances (3 feet wide) protected by buttresses, and we find the same labyrinthine plan of construction.

In "The Ruined Cities of Mashonaland" Mr. Bent refers to a description in Lucian's "De Syriâ Deâ" of a temple at Hierapolis which has much in common with the temples at Zimbabwe. Now Hierapolis, which was some distance to the north of Carchemish, one of the later capitals of the Hittites, is well within the Hittite country, and the worship of the mother goddess was paramount throughout the Hittite lands from the Euphrates to Ephesus, and from the South of Palestine to the shores of the Black Sea, and the evidences of nature worship found in the ruins of Rhodesia, and claimed as indications of the presence of the Phoenicians are quite as much, perhaps more, characteristic of the Hittites and of the earlier peoples of the Mediterranean, than they are of the Phoenicians or any other Semitic people.

Among the Rock sculptures of the Hittites at Fraktin (in Asia Minor) we find the representation of an altar on which is perched a bird on a small pedestal, reminding one of the birds on soapstone pedestals which have been found near one of the altars at Zimbabwe.

The construction of the elliptical temple at Zimbabwe is paralleled by the temples at Malta, and a similar structure is also found at Gozo, and we have the conical towers built of stone in Sardinia. All these structures in all probability long antedate any settlement by Phœnicians.

The decorative patterns, etc., which we find on the ruins in Rhodesia, we also find on the Hittite sculptures, and even the small grotesque soapstone figures which have been found in Mashonaland, although these may be of modern origin, are simi-

lar in appearance to small grotesque bronze figures which are found in Syria and Asia Minor, and are believed to be of Hittite origin.

In connection with the resemblance of a circular soapstone object decorated with rings of knobs which was found at Zimbabwe, to a similar object found at Paphos in Cyprus, it should be noticed that Cyprus was not occupied by the Phœnicians until a comparatively late date, and that so little were the earlier peoples of Cyprus under the influence of the Phœnicians, that they did not use the Phœnician alphabet, but invented a system of writing of their own, based on the cuneiform characters of the Assyrians.

The ruins of Rhodesia and the objects found there can be paralleled by similar ruins and objects found throughout Syria, Asia Minor and the islands and countries bordering on the Mediterranean, and it seems probable that it is in one of these countries that we must seek the original home of the miners of ancient times in South Africa. When we come to consider to which of these countries we must turn, we have the important fact that the Hittites were the miners of ancient times, and supplied the ancient world with most of the metals it required. They were the people who, learning perhaps that gold could be obtained on the coasts of a certain country, would be likely to think of penetrating and exploring the country, with a view to discovering and exploiting the veins from which the gold was derived. They also, alone among all the peoples to whom they were related by a common culture, had a powerful military organization, which would enable them to occupy and hold a country so extensive as was evidently at one time being exploited in South-East Africa, and they alone, among the peoples of their time, seem likely to have been able to send to the country experienced miners, sufficient in numbers to carry on mining operations so extensive.

In their own country the Hittites had trade routes guarded by lines of posts through Syria and Asia Minor; the great road from the Euphrates to the Ægean Sea can be traced to this day in some places where it passed over rock, by the two ruts made by the chariots wheels in the solid rock, and dominating as they did the tribes around them, had experience of the military occupation of great stretches of country.

The extent of the connection of the Hittites with the sea is uncertain. There is a tradition that Lydia was at one time the centre of a great maritime empire, and wild theories have been put forward on the subject. But in any case, the Hittites generally dominated or were in alliance with the maritime peoples of Syria and Asia Minor, and they also generally controlled or were in alliance with the Amorites and other Semitic tribes of Southern Palestine. It is possible that if they came to South-East Africa, they came in Phœnician ships, in the same way as we find in later times, the Phœnician navy at the command of the Persian King.

As it has been so frequently suggested that the mining in ancient times in South Africa was the work of Phœnicians. I ought perhaps to explain why it is that I think that the activities

of the Phœnicians in South-East Africa were confined to trading on the coast. As a matter of fact, I believe that the Phœnicians have been credited with an influence on the spread of civilization and with other achievements which are not their due. In the times between 1200 and 800 B.C., when the ancient peoples of Asia Minor and the Eastern Mediterranean were submerged beneath a tide of barbaric invasion, from both Europe and Asia, the Phœnicians survived, and to them the Greeks attributed many of the achievements of the group of peoples of which they were the sole survivors; in the same way as they attributed to the Phrygians, who were comparatively recent intruders into Asia Minor in the days of the Greek historians, a great antiquity, and many of the works of the Hittites who preceded them.

It will be noticed that the argument in favour of a Phœnician and even Sabæan origin is to a great extent based on the tacit assumption that the culture of Syria and the Mediterranean was of Phœnician origin. Recent discoveries, however, make it very doubtful if this was the case. It seems possible that, as is the case with so many old beliefs, we will have to abandon the belief expressed in the saying "*ex oriente lux,*" and have to admit that Western civilization to a great extent grew up in Western lands.

The parallel of remains of former ages found in Rhodesia, to similar remains found in the countries and islands of the Mediterranean, does not seem to me to point of necessity to Phœnician influence. I do not think it any more correct,—probably not so correct,—to ascribe the culture of the Mediterranean peoples to the Phœnicians, than it would be to ascribe Phœnician culture to the influence of the peoples of the Mediterranean and Asia Minor.

"It is now certain that the origin of our alphabet, for instance, is not to be found, as has been supposed, in the Hieratic script of Egypt, but in the Hieroglyphs of Crete; and that the influence of the Phœnicians in its development was less important than has been generally supposed."

At the present time also, there is little doubt that the main channel through which the civilization of the East reached the West, was the land of the Hittites.

In the 15th century B.C., as we can see from the Tel-el-Amarna tablets, each of the Phœnician cities had its own prince, and although they were rich in shipping, they had little political power and were tributary to Egypt or to the Hittites, according as the one or other of these powers was dominant in Syria.

Phœnicia was a small country, but a narrow strip of coastland, and its population must have been comparatively limited, and a large proportion of it engaged in trade and shipping. As they had no control over the inland tribes, it does not seem to me possible that they could have had at their disposal the men or military organization necessary to occupy effectively a country so extensive as that over which mining was carried on in ancient times in South-East Africa. So far also, as we have any real historical knowledge of the Phœnicians, we know that their settlements were always confined to the coast, and that they never penetrated far inland into any country. In the days of which we speak, the Phœnicians were traders and seamen, and not miners,

and although they no doubt would have endeavoured to stimulate the production of gold by the natives, it seems very unlikely that they would have penetrated hundreds of miles inland and exploited the mines themselves, and it is difficult to see whence they could have obtained the number of miners necessary to carry on the mining.

I think it probable that on the disintegration and submergence of the Hittite empire, the Phœnicians may have continued to trade in gold with such of the Hittites and their half-breed descendants, as may have been left in Africa, and that these may have continued to carry on mining operations for some considerable time, slowly degenerating as seems evident from the decadence we find in the later type of buildings, until finally, like their compatriots in Asia Minor, they also were submerged beneath a tide of barbaric—in this case Bantu—invasion, or possibly were driven by the Bantu to the South and West, when any extensive and systematic mining in South Africa came to an end; although no doubt some knowledge of gold winning survived, handed down from generation to generation and from tribe to tribe, and a certain amount of gold, sometimes more, sometimes less, was won and found its way to the coast through all the centuries, right down to recent times.

It was my intention to have discussed the possibility of finding traces of the ancient miners in the native populations of South Africa to-day, as it seems probable that these ancient miners would have left some trace of their long and wide occupation of the country in the language and even in the physical type of its original inhabitants. Owing to lack of time and opportunity, however, I have not been able to gather together such information as would justify me in discussing this side of the subject at any length. It may do no harm, however, if I notice briefly some points which had occurred to me.

The possession by the Makalanga and other Bantu peoples of South-East Africa of certain customs which are suggestive of Semitic influence, and the occasional occurrence among them of a Semitic type of Physiognomy, has often been noted. So far as these customs are concerned, however, they are not, generally speaking, peculiar to the Makalanga or any other tribe, but are found among Bantu peoples throughout Africa, and if they be derived from Semitic peoples, this Semitic influence must probably have been encountered in very remote times when the Bantu were less dispersed; probably at a time when they were in contact with Semitic peoples in North-East Equatorial Africa. So far as the prevalence of these customs may be greater in South-East Africa, and the undoubtedly more frequent occurrence there of a Semitic type require explanation, I think that they are easily accounted for by the constant presence of traders of Semitic origin on the coasts of South-East Africa, both in ancient and modern times.

When we consider the migratory habits of the Bantu peoples, and that the general trend of their migratory movements has been from North to South, it seems to me that the part of South-East Africa where we are least likely to find the descendants of the

people who inhabited Rhodesia 3,000 years ago, is in Rhodesia itself. It is not as if Rhodesia were a particularly inaccessible country where, for instance, as in the Caucasus, the remnants of Archaic tribes might remain secluded thousands of years after their relatives in the surrounding country had been submerged or swept away.

It seems to me doubtful, in fact, if 3,000 years ago there were many Bantu south of the Zambesi at all, and I think that if we would find the descendants of the ancient inhabitants of Rhodesia we must look for them to the south and west, beyond the limits flooded by the tide of Bantu migration. This of course suggests the Hottentots.

Now in the Hottentots we have a race that occupies a peculiarly isolated position, one whose affinities it is very difficult to ascertain. When South Africa was first discovered by Europeans the Hottentots were confined to the south and west of the continent, but there is evidence to show that in earlier times they extended much further to the north and east. It has often been surmised that the Hottentots are a mixed race and are descended from Bushman women and males of some unknown, but higher race, but there has been no agreement in the suggestions put forward as to the race to which these males belonged. There is a similarity in some of the grammatical peculiarities of their language to Berber and other North African dialects, and Berber is very possibly or rather probably related to the ancient pre-Aryan languages of the Mediterranean and Southern Europe.

The Hottentots are a dolichocephalic people, but their physiognomy is often suggestive of the Mongolian type, and if we turn to the Hittites, we find, in addition to the proto-Greek type from Western Asia Minor and the Semitic type from Palestine, a type which is distinctly mongoloid, characterised by a definite pigtail, oblique eyes, high cheek bones; in short a recognisable Tartar type. The Hittites themselves, that is the dominant tribe, the Hatti of the Assyrian inscriptions, are commonly identified with another type characterised by a long head, long nose and receding forehead, deep set eyes obliquely placed and yellow wrinkled skin.

The traces of moon worship among the Hottentots, their ancestor-worship, their superstitions, their belief in omens, amulets, etc., all suggest the possibility of some relationship with the peoples of Central Asia, and even possibly with the Hittites and the peoples related to them. The reputation of the Etruscans, for instance, for divination is well known. The evidence brought to light by excavation on the sites of Hittite cities tends to show a relationship of the Hittites with the early inhabitants of Turkestan. The early and constant association of the Hittites with the horse is also worth noting.

It is interesting to notice that amongst the Hottentots

"women were more nearly the equal of men, and were permitted to exercise much greater freedom of speech in domestic disputes than among most savages. They were mistresses within the huts, the stores of milk were under their control, not under that of their husbands, as was the case with the Bantu tribes. The men tended the cattle, but their daughters milked the cows."

It is interesting to compare this with the position of social and even political equality held by women among the Hittites. Men and women are represented as sitting down together to the ceremonial feasts, and to the treaties of the Hittites was affixed the seal of the queen, the great lady of the land, as well as that of the great king.

A study of the languages might throw some light upon this question, but of this I am not competent to speak. I do not wish to be guilty of a philology like that of a gentleman whom I once heard explaining that "Saku bona" meant good morning, and arguing from this that there was a relationship between Zulu and Latin; but it seems to me curious to find Bleek stating, on the authority of Von Klaporth, that clicks are found in certain Circassian dialects, especially when one considers that one of the possible clues to the interpretation of Etruscan lies in the fact that there appear to be resemblances between Etruscan and some of these Circassian dialects.

A name of the Hottentots for the deity (viz., Heitsi-eibib) also, reminds one of Tessub or Tisebu, the Hittite Storm and Sky God, who is represented with the lightning in his hand and standing on the back of a bull, and we have the statement of Lucian in "De dea Syria" that the chief god of Hierapolis was supported on a bull. Considerable progress has been made in recent years, in the decipherment of Hittite inscriptions, but what light this decipherment has so far thrown on the nature, the structure of the language, I am unable to say. The Hittite language, so far as I know, is neither Aryan nor Semitic, and is, to some extent at any rate, agglutinative in structure. The Hottentot language, which stands by itself among African dialects, is agglutinative with some traces of inflexion, and in some recent articles Mr. Van Oordt has shown that there are many resemblances between Hottentot and Mongolian roots. When one considers this and the Mongolian type found among the Hottentots, the Mongolian appearance of the Hittites and the probability of their early connection with the peoples of Central Asia, one is tempted to surmise that it was by this channel that possible Mongolian blood and Mongolian speech reached South Africa.

My impression of the whole matter, and it is an impression only, is that from very remote times gold was obtained from the coast of South-East Africa by traders, possibly at first by Sabæan Arabians and subsequently by Phœnicians, that the Hittites learning this sent expeditions to penetrate into and explore the country and exploit the gold mines. At that time I think it probable that there were comparatively few Bantu south of the Zambesi, but that they were even at that time endeavouring to settle there and were only kept back by the Hittite military organisation and system of fortifications. I think it probable that on the disintegration and subsequent submergence of the Hittite empire, the Hittites remaining in the country and their half-breed descendants, from whom the Hottentots are probably derived, continued to mine for gold and to dispose of the gold they won to

Phœnician traders on the coast, but that finally, unable to stem the tide of Bantu invasion, they were driven from the country to the south and west, and systematic gold mining in Rhodesia came to an end; and one is tempted to suggest that, unsettled and kept on the move by their Bantu enemies, they reverted to the nomadic habits of remote ancestors in Central Asia.

This paper is far less complete than I could have wished it to be; but I hope that it is not altogether without interest, and even that it may be of some use, if only in the way of stimulating the discussion of the problems suggested to us by the presence in South Africa of, on the one hand, what we may term a derelict race, and on the other, of the forsaken outposts of the forgotten civilization.

RANDOM NOTES BY A SCHOOLMASTER.

By A. S. Langley.

(*Not printed.*)

CHEMICALLY ACTIVE NITROGEN.—Strutt, in a recent communication to the Royal Society *(Proc. Roy. Soc.,* 1911, pp. 219-229), states that pure nitrogen, subjected to an electric discharge from a Leyden jar, in an exhausted tube, is so modified that it acquires a glow which persists for some time after cessation of the discharge. This modified nitrogen, which has a characteristic band spectrum, loses its luminosity when heated, but recovers it on cooling. A temperature approaching to that of liquid air causes an increase of brilliancy, but when that temperature is actually reached all luminosity is lost. The modified nitrogen reacts violently on mere contact with ordinary phosphorus, altering the latter into the red form. Iodine causes the yellow glow of the nitrogen to be replaced by a light blue, accompanied by a slight rise of temperature. The new modification of nitrogen, if gently heated with sodium or mercury, enters into combination, forming in the latter case an explosive compound. With organic halogen compounds this form of nitrogen reacts in such a way as to set free the halogen, itself combining with the carbon to form cyanogen. It acts on Nitric dioxide forming the tetroxide, the reaction being accompanied by a green flame. The luminosity of the new modification of nitrogen is destroyed by ammonia, by cupric oxide, and by manganese dioxide, but is not affected by either water or carbon dioxide.

THE GROWTH OF AN UNIVERSITY.

By Julia F. Solly.

Much has been written and said concerning a teaching University for South Africa, one worthy of our country, properly equipped for scientific research and that shall contibute to those newest sciences, ethnology and anthropology, as only South Africa can; sciences every day more important now that an awakened European conscience is striving to understand and guide, not merely crush and exploit, races of different civilisations and development from our own.

In most of the talk, on press, platform, or in council room the demand is largely for money and equipment, the demand for both being so great that it is stated only one such University can be expected of Government, which is looked on as the proper source of supply.

It seems to me that money and equipment, though necessary to a University, are not the only or even the main things, and that the two main requirements—teachers and students—have not been sufficiently considered or, rather, hardly even glanced at, and the University we all hope to see is apparently to spring at one bound into full and active complex existence, as Minerva sprang fully armed from the head of Jupiter, if only the Treasurer-General will give public money enough.

A brief sketch of the growth of a successful modern University, that of Liverpool, might be of service, and if I lay stress on other than pecuniary requirements, it is not because as a member of the paying—though unhappily not of the voting—public, that I deprecate money being spent on a University, but because I do not think a million, or two millions, or three millions will make a University.

Some time ago the *Transvaal Agricultural Journal* published views of leading Educationists all over the world as to the aims and ideals of a National College of Agriculture, and a detailed plan for University education was privately circulated, drawn up by one of the most enthusiastic and brilliant of the Liverpool professors.

Twenty-nine years ago the Committee formed in Liverpool to promote a University, bought a disused lunatic asylum, added one large lecture hall and a few outhouses, and started with seven endowed Chairs and a few lectureships. I was a student there from 1883 to 1890, usually one of a class of two, in two cases a sister was the other one. We were amateur students, *i.e.* not studying for a degree, but merely in pursuit of knowledge. The financial value of each Chair was £400 a year* and half the fees, and the first seven were: Greek, Literature, Philosophy, Physics, Chemistry, Natural History, and Mathematics. Just now it is of interest to note that the Gladstone Chair of Greek was founded by three admirers of the Right Hon. W. E. Gladstone, who was a native of Liverpool and an enthusiastic classical scholar.

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*The minimum is now £600

In a commercial seaport one would hardly have expected Greek, Philosophy and Literature to be the first, and Naval Architecture to be the last Chair to be founded; but the Chair of Naval Architecture was founded only last year, and up to the present the Arts side has been well supported, unlike what has happened in some other modern universities.

In 1884, University College, together with Owens College, Manchester, and the Yorkshire College, Leeds, were incorporated as the Victoria University, and the excellent Medical School already in existence at Liverpool was amalgamated with University College, bringing on to the Council a body of able and practical men, notably the late Sir Michael Banks, first Dean of the Medical Faculty, whose caustic wit and common sense is still remembered on the Council, while his happy phrase "a quadrangular mind" is still used to describe the man who, brought up at one of the older Universities, can only appreciate modern ones in so far as they copy Oxford or Cambridge, instead of developing on their own very different lines.

Among the first professors were Dr. Rendall, now at Charterhouse; Professor Bradley, now filling the Chair of Poetry at Oxford; Professor MacCunn, who retired a few months ago, author of "Ethics of Citizenship" and other philosophical works; Sir Oliver Lodge, now head of Birmingham University; and Dr. Herdman, who is still at Liverpool and known to many of us as General Secretary of the British Association for the Advancement of Science.

Sir Oliver Lodge combined the varying attributes of an inspiring teacher, a fine scientist and an admirable public speaker. He was at Liverpool from 1881 to 1900, but the present fine Physics Laboratory was built only in 1904; and Sir Oliver worked out many problems and pursued his elaborate researches with very elementary equipment; nevertheless, before Marconi was heard of except by his teacher, Sir Oliver Lodge had a wireless installation of telegraphy between College and his private residence, and during the later years that he was there he was wont to dispel the fog that besets the valley of the Mersey by means of electric discharges, so that the University area was always clear of fog, proving the practicability of one of his many theories. His fascinating book "Pioneers of Science" first appeared in lecture form in connection with University Extension Lectures.

Dr. Herdman's achievements are even more remarkable. Starting with two or three rooms, a very small museum and an outhouse or so, he has built up a fine School of Biology, a Marine Biological Laboratory second to none, and a permanent Fisheries Exhibition. The excellent Botanical Laboratory, where his former demonstrator, Mr. Harvey Gibson, is professor, may be regarded as an offshoot of Dr. Herdman's work, and the School of Tropical Medicine is so likewise. In 1897 most of the old buildings had been handed over to Dr. Herdman, as from 1890 onwards there was constant building of new departments, and the main buildings of University College were in their present positon in 1893. In that year he and Mr. Boyce (who had come from London to join him) were elaborating experiments on oysters to ascertain how far

sewage made them unfit for human consumption, and from that combination the School of Tropical Medicine developed, of which the results are sufficiently striking, as well as valuable, to be known even to the man in the street. Of that School Sir Rupert Boyce is Dean and Major Ronald Ross* leading professor.

When the Imperial Government required expert knowledge on the Ceylon Pearl Fisheries, it was to Dr. Herdman and Liverpool that they applied. Dr. Herdman and a number of assistants went out to Ceylon, discovered the cause of the trouble, found a remedy, made certain recommendations, which have been successfully carried out, and returned with large and valuable collections from the Indian Ocean, to add to their admirable and varied Museum.

About 1889 Dr. Herdman obtained permission from the owner of Puffin Island, off Anglesea, to erect a few sheds and form a little laboratory for Marine Biological research; the Dock Board graciously lent a derelict tug to the enthusiasts (Dr. Gilchrist doubtless remembers the unseaworthy propensities of the *Hyæna*), and from that has grown the splendid Marine Biological Laboratory at Port Erin, one of the best equipped in the world. Doubtless Dr. Herdman at times envied his brother biologist, the Prince of Monaco, an equally distinguished scientist, whose lines were laid in softer places; but millionaire princes, who are also scientists, cannot be expected to materialise often until the day foreshadowed by Plato, when kings shall be philosophers and philosophers shall be kings. Meantime, it is the man who makes the opportunity, and, as Dr. Herdman told someone when here, "the great thing is that Liverpool gives you a free hand and you can develop on your own lines." Originally he had little equipment, and, like all the other Chairs in the early days, his income was £400 a year and half the fees; the class that I was in consisted of ten, other more advanced classes of fewer. Like Sir Oliver Lodge's, so Dr. Herdman's career contradicts the theory that money and equipment are the first needs of a University; the first, second and third are good *men*, teachers and searchers with a free hand.

In the town from which the first passenger train and first railway started one expects engineering to be of importance, and so in 1885 a lecturer was appointed, Mr. Hele Shaw, who again with the minimum of equipment made himself felt at once and attracted students. In 1886 a Chair was established, and in 1887 the Engineering Laboratories built at a cost of £30,000.† Professor Hele Shaw continued at Liverpool until he resigned to come to Johannesburg in 1902. In 1884 Chairs of Latin and History had been added to the foundation and College was equally fortunate in these professors, though there is less that can be easily recorded. Dr. Strong, first holder of the Latin Chair, retired last year on the age limit; he was an enthusiastic member of the Classical Association and a keen archæologist, rousing his students to investigate and help to disclose the Roman remains of Cheshire and the Welsh Marches.

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*Nobel Prizeman.
†Built by a private citizen.

Professor John McKay, first and only Professor of History, is one of the most whole-hearted supporters of the University. Though himself an Oxford man, loved and admired alike by colleagues and students, he is one of our most valuable elements. When some years ago the Record Office desired the best paleographer that could be found to decipher historical documents in the Vatican Library, it was one of his pupils, Mr. Twemlow, who was selected, and he in his turn now holds a lectureship founded "in honour of the attainment of the holder," a phrase frequently met with in a record of the Chairs and lectureships of Liverpool University.

In 1903 the Victoria University split up, Manchester, always the centre, retaining the title, and still giving Victoria University degrees; University College became the Liverpool University, the Yorkshire College, Leeds, becoming the Leeds University, an honour Leeds most reluctantly accepted.

The effect was immediate. I was present at the first degree-giving in 1904; the largest hall in the town, St. George's Hall, was filled. The Lord Mayor attended in state and offered £10,000 a year from the City Council; the Mayor of Birkenhead, the town across the Mersey, offered £1,000, and the Mayor of Bootle £500 a year. Her late Majesty, Queen Victoria, as Duchess of Lancaster, divided £10,000 between Liverpool and Manchester, which at Liverpool was supplemented by the Earl of Derby to form a Chair of Jurisprudence. I believe Manchester and Leeds also rose to the occasion. At the same time four new Chairs were endowed with the usual £10,000 by private citizens, the civic spirit was roused, and the town felt and recognised that it honoured itself in honouring the University. Are not all Universities outside the New World connected with a town? Oxford, St. Andrews, Paris and Bologna, Leyden and Heidelberg, Barcelona and Alexandria, and should not the proposed South African University be definitely associated with the Mother City of South Africa?

Since 1904 the progress of Liverpool has been amazing. Last July over 200 students took their degrees. Among them one saw with interest men of alien race and colour, Chinese, Japanese, Indian and Egyptian, attracted of course to mechanics, physics and engineering, where, as Marquis Tseng truly said Europe is greatly in advance of the East, he added equally truly, "But in agriculture, first and greatest of sciences, Europe is 300 years behind China." In South Africa, where so much depends upon agriculture, we may perhaps do away with that reproach.

Among the newest developments are the School of Architecture and the School of Archæology and Anthropology; not what one would have anticipated. The School of Architecture has recently been housed in a beautiful Queen Anne building, formerly the Blue Coat School, and students come to it from all over the world, including South Africa and Manchester. One needs perhaps to be a Lancastrian to appreciate the force of the latter tribute to Professor Reilly; with it is associated the department of Civic Design, including Hygiene, and together they publish

the *Town Planning Review,* a monthly magazine. The Professor of Architecture was appointed in 1904, but only this summer was his Department suitably housed.

The Museum of Archæology awaits suitable housing. At present it is in two houses in the terrace near the main University Buildings, but its contents merit a finer place, for it contains the one Hittite vase in Europe, placed there by Prof. Garstong, Professor of Archæology; many things from Crete and Mycenæ, procured by Prof. Bosanquet, one of the Cretan explorers; treasures from Egypt brought by Prof. Newberry, or lent by local owners; and, the most interesting of all, because breaking entirely new ground, figures and vases, implements and ornaments, from the forest region of Honduras, remarkable in that no metal of any kind is found among them, even tools and weapons being of obsidian. These are lent to the Museum by Dr. Gamm, who, coming over to study at the Tropical School of Medicine, found a hearty welcome also from the professors of anthropology and archæology. Dr. Frazer, the distinguished author of "The Golden Bough" and "Psyche's Task," holds one of the Chairs, "founded in honour of the scholarship of the present holder," as the calendar expresses it.

All this is very remarkable; one understands easily the development of the Marine Biological Laboratory and the Tropical School of Medicine from Dr. Herdman's Zoological Department; indeed the latter is a sort of tardy compensation for the slave trade that for generations formed Liverpool's sole connection with the West Coast of Africa; one understands, too, how there should be four well-equipped Chemical Laboratories, for S.W. Lancashire is a great Chemical centre, and Manchester has long been renowned through the work of Roscoe and Schorlemmer. One Laboratory (that under Dr. Moore for bio-chemistry) is solely for research work, and one (under Dr. Donnan—physical chemistry) mainly for research work. Dr. Donnan tells me that it is the only laboratory of its kind in England and one of the very few in Europe, and both he and Dr. Moore ask why they have no students from South Africa, as they have from all the other main Colonies. But the success of the Archæological Department is only attributable to the attainments and personality of the present professors, one of whom, Prof. John L. Myres, Oxford has created a Chair for, so as to get him back to her; a compliment well merited.

There are many other lines of progress, many men equally worth mentioning, but the main points I am trying to emphasise are the same in every department; if a good man is found, he is glad of the opportunity offered; first a lectureship, then a Chair, then a Museum or a Laboratory or a fine building; the men I have named are widely known; the departments I have detailed are well-known, and in a few words the growth can be summarised. The seven original Chairs have increased to 49; the nine original professors have increased to 43, with 192 assistant lecturers, professors and demonstrators, not including in that number readers in Icelandic, Chinese, Celtic, and Ethnography. The small rooms in which the first absolutely necessary specimens were housed have been succeeded by 14 museums, one of which

I have ventured to particularise. There are 18 laboratories, all equipped for research, some of them unique. Practically the whole of this has been done by private citizens "holding the love of learning better than riches and the pursuit of knowledge higher than the pursuit of gain," as Dr. Rendall's inscription runs under the bust of the donor of the Tate Library. Libraries are a point I have omitted, as I fear to waste time; the growth here corresponds to the rest.

Surely there is something to be learnt in all this for us here; it is not money or even equipment; here where you have many fine buildings and men ready to your hand; surely it is not becoming to those who believe they have the true University spirit to make so great a point of the millions they require from the State.

Would it not be possible for a Committee of this Association to be formed to enquire into what could be done with the buildings and men we have; laying before the Minister of Education a minimum of what will be required to start at once, both as to money, Chairs and equipment, and specifying also those men, who in the Committee's opinion, owing to their attainments or their researches, should be specially provided for in any University. I gave Prof. Myres the recently-published book of Bushman Paintings" by Miss Tongue and Miss Bleek, and the March and April numbers of the magazine of this Association. He said: "The book I know of and am glad to have for our library, but I did not know till I read the magazine that so much first-hand knowledge of the Bushmen was still available." In any University you will need first of all to secure the services and give the opportunity to men in this community who have first-hand knowledge of our native races.

One final word, the motto of the town of Liverpool is: "Deus nobis haec otia fecit"—"God gives us leisure"; the motto of the University is: "Haec otia studia fovent"—"this leisure favours study"; what fine field for choice of a motto for the Cape Town University in the words "Spes Bona."

NOTE I.

Liverpool is not a residential University, few of the modern ones are. In Germany it is usual to provide a residence for the leading professors, attached to whatever Laboratory they preside over.

NOTE II.

The following figures have been supplied by Mr. Hugh Rathbone, Treasurer of the Liverpool University:—

1882	Professors, ...	10
1910	Professors, ...	43
1885	Students, ...	274

(No record before; this includes evening students.)

1910	Students, ...	1,032

(Evening students and research students not included.)

Gross income, all sources:—

1882	£5,478
1892	14,015
1902	29,000
1904	53,162
1910	75,566

The Public Grants are:—

£10,000 from Treasury as College.
2,000 from Treasury as University.
2,500 from Treasury, Special Grants.
10,000 from City of Liverpool, less £1,000 for scholarships of City students.
1,771 from City of Liverpool as Technical Money.
1,050 from Lancashire County Council.
500 from Birkenhead, less £250 for Birkenhead scholars.
400 from Bootle, less £150 for Bootle scholars.
400 from Cheshire County Council.
100 from St. Helen's.

THE PLANETESIMAL HYPOTHESIS.—In the *Transactions of the Academy of Science of St. Louis,* Vol. XIX., No. 9, C. R. Keyes discusses the possible bearing upon the planetesimal hypothesis of the origin of the earth of the abundance of meteorites occurring on the Painted Desert, in north-eastern Arizona. On the borders of the desert is a remarkable truncated cone, known as Coon Butte, in the vicinity of which an exceptional abundance of meteoritic material is to be found, and local tradition has long ascribed the depression in the top of the hill to meteoritic impact. The author of the paper, however, concludes that Coon Butte is probably of volcanic origin, numerous similar phenomena in the vicinity showing undoubted connection with the explosive type of vulcanism. The great abundance of meteoritic material in the neighbourhood he ascribes to favourable climatic conditions, coupled with marked deflative activity on a hard rock stratum, rather than to extensive comminution of a huge meteorite. Desert regions he considers to be exceptionally favourable for the disclosure of abundant meteoritic material, compared with moist lands; it is not that meteoritic falls are more frequent in desert regions than elsewhere, but that the anomalous climatic conditions tend to give them greater prominence. The chief meteoritic augmentation of the earth's volume he considers to be in the form of dust, of which the abundance of metallic grains in desert soils and arctic snows is evidence. The principal ultimate source of ore materials is regarded as possibly meteoritic in character rather than magmatic.

NOTES ON SOME BUSHMAN PAINTINGS IN THE THABA BOSIGO DISTRICT, BASUTOLAND.

By M. Wilman.

During a week's *trek* in the Thaba Bosigo District, undertaken in October last under the auspices of this Association, the writer was so fortunate as to be able to examine and to make tracings* of some paintings by the early inhabitants of the country. They are not numerous, at least those known to the natives who accompanied the party and to those questioned on the way are not numerous; but some of them are of interest and seem well worth recording.

Most of the paintings are on the more or less perpendicular walls of the so-called "caves" of the Cave Sandstones, of which so much of the country is formed. The "caves," however, though often immense, are seldom of any great depth and are better described as "rock-shelters."

On the spurs of Thaba Bosigo, a long and arduous climb brings one to the cave-dwellings of *Ntloklolo*. Here, we had been assured, were paintings by the Baroa.

The cave-dwellings, perched high up, along a very long, narrow ledge of rock with gigantic caves, proved of exceptional interest; but the paintings near them had almost vanished. Some had faded; some, apparently the older and better ones, had been scratched over and nearly obliterated; while all were so far above the level of the floor of the shelter that it would have been impossible to make tracings of them, even had they been worth the trouble.

At a little distance from the dwellings, however, a few paintings were found, some of them so faded that they could only be traced after having been carefully sponged over.

Unlike those just referred to, these proved to be miniature paintings of human beings and of animals, the less faded ones being not of the common light-red paint, but of a dull dark-red colour, made probably from micaceous hæmatite, a mineral much favoured by the Bushman.

They exhibit no great skill in draughtsmanship, no variety whatever in technique, and appear to be of comparatively recent date; but they are of interest because they are so characteristic of the district, similar ones being almost everywhere met with, dotted among the larger, finer and probably older pictures.

Near Little Roma is the Basuto place of execution, a steep place where formerly criminals were simply and easily disposed of, by being hurled down headlong.

Hard by is *Baroeng,* the place of the Baroa; a couple of protruding rocks, with a landscape of quite extraordinary extent and beauty stretching out beneath them. *Here,* the inhabitants were positive, were paintings by the Baroa. Yet the first impression was one of disappointment.

*These, together with the reproductions made from them, are now in the collection of the McGregor Museum, Kimberley.

A careful search, however, brought to light what seemed to be engravings of somewhat unusual outline, but were in reality the remains of paintings from which the colouring matter had been so carefully scraped that the original outlines, of elands and other animals, had been preserved entire.

The care with which the pigment had been removed seemed at the time very extraordinary, but the writer has since been informed by Mr. T. L. Fairclough, of Wepener, who knows the Basuto well, that they were in the habit of using bushman-paint as medicine, and the object probably was to collect as much of it as possible.

Matlakeng, the place of vultures, not far from here, is a ledge of rock reached after a weary climb, with shady roof, vultures, and a number of paintings, some of them much faded.

These include bucks, women and men (?) as portrayed by the bushman or the bushwoman, and forms nearly circular ($2\frac{1}{4}$ inches in diameter) with appendages, that seem to be crustaceans—"Things that swim about in our pools," said the Basuto guide.

At *Mohlaka-oa-tuka,* which, being interpreted, means a burning moor, close to a Basuto village, are paintings that the Association party were, for once, able to climb *down* to see. Here there is a wall of somewhat exposed rock, having a strip—some 36 feet long and 6 feet deep—covered with what at one time must have been very beautiful paintings of well-drawn antelopes and other animals in rich and varied hues, and with little dark human figures like those above referred to, as being probably of a later date.

In one case, however, that of a large buck rearing and two pygmy hunters, the latter seem to fit the scene except for their minute size and the greater freshness and the inferior quality of the colour used to depict them. This may of course be the result of touching up at a later date, and a lack of proportion is only too common in bushman, and other, paintings.

The larger animals have had to pay a heavy penalty for their proximity to a village and a high-road, and the elements too have dealt so unkindly with them, that it was impossible to determine whether at one time they may not have been parts of elaborate compositions, though occasional little scenes remain that seem to suggest this.

A few tracings were obtained shewing the eland in a variety of attitudes that are a pleasing change from the usual side view. The dark colour of the bodies must have been originally of a rich red, and where this meets the cream tint of the necks there is sometimes what might be considered as shading, but more probably is due to the running of the paints when fresh or later on from decomposition.

*Niappering** is near the village of the chief Theko, and not far from Machache, the object of our pilgrimage. Here there are paintings that are well worth even a very long journey.

A ride from camp across many a ploughed mealie-field and a

*Referred to as "Theko's Village" in "Bushman Paintings," copied by M. Helen Tongue, with a preface by Henry Balfour. Oxford, 1909, 4 to, 48 pp., 2 chromo collotypes, 54 col. pls., 8 illustr., map.

steep climb down, astride a Basuto pony, and the enthusiast reaches one of those delightful streams that add so much to the charm of the Lesuto.

On the far side is a large rock-shelter, consisting of a great wall parallel to the stream, a lofty, arched roof, and low stone walls, dry at one, the most sheltered end, at the other end wet from the constant drip from the roof.

Here, judging from appearances, large numbers of cattle constantly find shelter, where at one time the Bushman must have dwelt in great contentment.

At the sheltered end, from a few feet above the level of the floor up to some seven or eight feet above it, there are the still splendid remains of a most bewildering collection of paintings of various periods—of battle-scenes, of raids, of processions of men and of beasts, and of single animals, here scattered about over the surface of the rock, there so crowded together, sometimes even one over the other, that the walls, naturally a deep cream, are even to-day aglow with colour; and before the advent of the Bantu and the European must have presented a fresco of quite extraordinary beauty and interest.

Towards the exposed end the paintings thin out, and finally are altogether wanting. Possibly this may be due to the damp, probably there never were any here.

The most striking composition, very appropriately placed "on the line," is a procession of mighty elands, from 28 to 36 inches from tip to tail, sometimes marching two abreast, and painted more often than not over a host of smaller animals.

The elands are not well drawn, are indeed badly proportioned, and little attention has been shewn to detail; but their number and size attract, as does also the extraordinary richness of their colouring.

As a rule, the head, neck, belly and legs are of a dirty cream, evidently once white, while for the body a very deep rich red has been used, probably the better to conceal the handiwork of the earlier artists.

Of this dark paint the quality is extraordinary, for it has the brilliancy and gloss of oil-paint, which medium indeed is the only one that can adequately reproduce it; while through it, and at the edges, there shines a rich vermilion tint.

The excellence of the pigment may be due partly to the fact that having been applied to an already painted surface, it did not sink in; but it also seems to have been mixed with unusual care.

The presence of the vermilion is not easy to account for. It may have been used as a first colour, or the dark paint may have been made by mixing two shades of red; but most probably this again is the result of decomposition of the pigment.

Yet in spite of this it has even now a fine quality not found in either the earlier or the later paintings in this neighbourhood.

Of the paintings that formerly adorned the walls here, very little now remains besides innumerable limbs of animals. These appear to have been well drawn and coloured in a variety of rich, though not dark, shades of light-red and burnt-sienna, varied with cream, and to have been in quite good condition when the large

elands were painted over them.

On other parts of the rock again are a number of smaller animals depicted in groups or singly in a variety of attitudes—elands, smaller antelopes, jackals, birds. They are coloured in various shades of red, yellow-ochre and sienna and in cream, and the drawing is often very spirited and unconventional.

The pair of beautiful blue cranes (*Tetrapteryx paradisea*), reproduced by Miss Tongue,* belong to this series.

Some of them may be older than the elands, some may be of the same age; others are undoubtedly of more recent date.

Of later date again than these is a collection of battle-scenes, raids, processions of human beings, single pygmies, monkeys, snakes and winged creatures that fill up the spaces between the older paintings, but do not seem to encroach on them.

The pygmies and the animals are of very inferior technique, and are in various shades of dull, dark-red, burnt umber, yellow-ochre and in white. Unfortunately many of them have not only been damaged in a variety of ways, but they have been touched up, with white paint, it is to be feared by some European artist!

The winged creatures are so extraordinary that they baffle description, but some have been copied by Miss Tongue† and the writer. The snakes too cannot be said to slavishly imitate nature.‡

Of extremely inferior technique and much damaged are the battle-scenes and processions, but they are nevertheless of great interest, as some of them seem to illustrate a chapter in the history of the Basuto—their invasion of the country of the Bushman, their wars with other Bantu tribes.

A couple of these have been copied, at least in part, by the writer; of the others it seemed impossible, at any rate in the short time available, to make connected pictures.

One shews what appears to be Bushman in ambush, and the victorious Bantu raider going off with prisoners; in the other lines of Bantu warriors are drawn up in battle array; while Miss Tongue has reproduced a number of natives in blankets.|| The figures here are all small.

The drawing is beneath contempt, but allowance should be made for the probably greatly harried artists. The pigment is monotonous, being of the common dull dark-red, often, however, much faded.

As for the age of the paintings, the old chiefs of the district, men of at least sixty years old, declare that even when they were little children, no Bushmen were living near them; that they had all moved off "yonder," pointing to Machache, and only occasionally came down to raid their cattle.

The most recent paintings must therefore be over 50 years old, and we have seen that there are at least four periods of them.

The paintings have been destroyed wantonly by native herd-

*l.c., p. 32, pl. XLI., No. 79.
†l.c., pl. XIX., No. 101: pl. XLV., No. 80.
‡l.c., pl. XIX., No. 101.
||l.c., pl. XV., No. 102.

boys and by Europeans, some of whom have had the impudence to leave their mark; by exfoliation of the rock and other weathering agencies; by smoke from fires, sometimes of the circumcision lodges which are frequently housed in the shelters; by the rubbing against them of cattle; the splashing over them of unsavoury cave deposits and the chemical action of these. Indeed, when one considers the variety of the destructive agencies to which they have been subjected, the only wonder is that any remain to tell the tale of their former glory.

But even as they are, in ruin, they are well worth preservation, and the writer cannot but think that it is the duty of this Association to urge the Government of Basutoland to take measures speedily for the preservation of works of art that, with care, might continue for many a year to adorn the rock-shelters of this fascinating country.

Other relics of the Bushman, such as skeletons, ornaments and implements, were not found in the shelters; but the recent deposits on the floors are so thick that, without excavation, this was scarcely to be expected.

A few agate arrow-heads were picked up on the summit of Thaba Bosigo, and other implements would probably have been found, had it been possible to make a careful search.

The old chiefs and natives were much amused by the interest shewn in the puny Baroa, but they were most willing to give whatever information they could about them. Unfortunately, this amounted to very little.

As for the young Mosuto, he seems neither to know, nor to care, about the history of his race and of his country.

THE PROPOSED NATIONAL BOTANIC GARDEN. —The recent decease of Dr. H. Bolus, F.L.S., and his munificent bequest to the South African College, for the purposes of botanical study, will impart an added interest to his views on the establishment of a National Botanic Garden. Scarcely four months have passed since those views were placed on record in the form of a letter to Prof. Pearson, who has kindly permitted its publication. Dr. Bolus wrote as follows:—"My dear Pearson,—It is now some time since you were so good as to send me a copy of your address as President of Section C of the meeting of the South African Association for the Advancement of Science, in which you so ably advocated the establishment of a National Botanic Garden. The subject, of course, was not a new one; since it was first brought forward many years ago. But it is simple justice to say that never before have all the arguments in its favour been so systematically and convincingly marshalled as to show to every one who will take the trouble to read them the immense importance of such an Institution, and the great advantages to the progress and well being of the new South Africa, even from a material point of view, which might be expected to flow from it.

"The period of your address was admirably and most happily well-chosen. The establishment of the new Union had filled the hearts of every lover of South Africa with fresh hope for the future, and all were ready to welcome any prospect of a step forward in the way of progress towards combination in efforts for the establishment of institutions for the promotion of science and art which have done so much and proved so beneficial in the life of older countries.

"This being so, it is natural that there should have arisen both regret and disappointment that so few visible signs have appeared of any tangible results from the Address. It must be recognised and admitted that here in South Africa, as in most other countries, there has been shown rather too strong a tendency to look to the Government for the initiation of any important step in our National life. This is only natural in comparatively poor communities. But it is a tendency which must not and will not last for ever. The work to be done in this case is too vast to be left to individuals. Over the whole of South Africa, from the Cape Peninsula to the Transvaal, and even to Basutoland, there have been isolated workers engaged in collecting and investigating the flora of the country, stimulated and assisted so far as may be, by students in the more populous centres of the southern coast. A great deal has been done in this way, without show, but not without cost, both of time and money, in laying the foundations for further advance on which would be erected public centres to serve as a means for pushing forward the work of investigation of our native vegetation. In the science of geology much has been done, and the work of the Geological Commission, which is beyond all praise, has, under the fostering care and the liberal support of the Government, made such progress as to inspire us with the hope that a similar encouragement to the no less important science of botany which has been left so severely alone, would lead to equally valuable results.

"The new Government is no doubt wise in proceeding cautiously. But there are some who think that at least the subject might have been discussed in an inexpensive manner by the appointment of a Select Committee of Parliament, which might have suggested a modest beginning, if only in the way of reforming and extending some of the smaller existing gardens in or near the older towns.

"I quite agree with your view that a beginning should be made in the establishment of one chief garden combining horticulture with a botanical museum and library, without which last very little can be done. In such matters as these we must avail ourselves of the experience of older countries, and you have very well shown how all the finest gardens in the world have been established near the centres of population. The great thing, one of the most important things, is to ensure the interest of the public. The one British Institution which is the constant admiration and envy of foreign visitors to England, is the Kew Gardens, and besides the Gardens proper, the Museums, the Library of over 30,000 volumes exclusively on botanical subjects,

and the herbarium are visited every year by numbers of botanists from every part of the world; and in the gardens special beds are laid out which may be visited by the botanical classes from the London schools, and where, under proper and reasonable regulations, students are allowed to gather flowers for examination.

"It is perhaps not very obvious except to those who have paid attention to the subject, how great is the educative value of the study of the native vegetation of the country; girls especially, soon learn to take a great nterest in it, and even from isolated students in farmers' families unknown to me I have often received specimens and applications for information and names. Of course this is mostly a continuation and result of botanical lessons learnt at school or college, but they are a source of great pleasure and a relief from the drudgery of every day housework.

"Once the establishment of a National Garden is decided upon and the needful funds voted, will come the selection of a place, and here it may be feared will arise some thorny discussions, although these are of minor importance. It must be conceded that some spot in the neighbourhood of Cape Town must be chosen. The precise locality is of secondary importance since there are many eligible spots, scarcely any of which could prove a failure. The indispensable requirements are, a reasonable nearness to the city, a shelter from high winds, a good water-supply, and a fairly good soil.

"To conclude, I think that any one who has been like myself a long-time resident in the Colony, must have been struck by the very remarkable increase in the number of garden-lovers of late years, and especially by their enthusiasm, and this must grow even whether we help it, as being convinced of its goodness, or not; and we cannot forget the words of the great sage:

> 'God Almightie first planted a Garden. And indeed it is the purest of Humane pleasures. It is the greatest Refreshment to the Spirits of man; without which, Buildings and Palaces are but grosse Handy-works; And a Man shall ever see, that when ages grow to Civilitie and Elegancie Men come to build stately, sooner than to garden finely; as if gardening were the Greater Perfection.'"

TRANSACTIONS OF SOCIETIES.

SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS.—Thursday, May 18th: Mr. J. H. Rider, V.P.I.E.E., President, in the chair.—"Switches and Switchboards": G. H. B. **Bernard.** The author reviewed the development of modern switchgear, and referred to the principles requisite in designing gear suitable for modern requirements, mentioning the causes which led to the introducton of successive improvements. He then described in detail the more important apparatus, dealing with the considerations necessary in selecting gear for particular cases: he also described the materials employed in the construction of switchboards, and discussed the main principles underlying switchboard design in general

South African Society of Civil Engineers.—Wednesday, June 14th: Mr. A. D. Tudhope, M.I.C.E., in the chair.—"Notes on Road construction": R. W. **Menmuir.** The suitability of road making materials was dealt with and information was given in connection with the cost of roads constructed in the Cape Peninsula.

Royal Society of South Africa.—Wednesday, June 21st: Dr. A. M. Wilson, in the chair.—"Notes on the principal systematic work and publications dealing with the South African Proteaceae"; E. P. **Phillips.** Beginning with the first record of Clusius in 1605, the author went on to refer to Boerhaave's study in the 18th century and the work of Salisbury and R. Brown in the early part of the 19th. In Meisner's monograph, dated half a century later, 279 species are described. The author has undertaken a revision of the order and has recorded between 300 and 400 species.—"The spectrum of the ruby; and the artificial ruby": Dr. J. **Moir.** A complete spectrum of eight hair lines has been observed: these are best seen in the artificial ruby, which is in every respect identical with the natural gem, and even its superior when free from flaws.—"Notes on the spectrum of the precious emerald, and other gem stones": Dr. J. **Moir.** The emerald spectrum contains three very distinct hair lines in the red. Sapphires have no hair lines in their spectrum. Indefinite spectra are yielded by artificial emeralds, rubellite, spinel, amethyst, fluor, aquamarine, rose quartz, lepidolite, and topaz.—"Note on the land and sea breezes of South Africa": Dr. J. R. **Sutton.**

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Brooks, Edwin James Dewdney, C.E., Resident Engineer, Waterworks, Umtata, Cape.
Broom, Robert, M.D., C.M., B.Sc., C.M.Z.S., Victoria College, Stellenbosch, Cape.
Brown, Professor Alexander, M.A., B.Sc., South African College, Cape Town.
Brown, Mrs. Hannah L., Glen Avon, Somerset East, Cape.
Brown, John, M.D., C.M., F.R.C.S., L.R.C.S.E., Keb Cote, Glebe Road, Rondebosch, Cape.
Brown, Dr. Johnstone, M.B., C.M., P.O. Box 94, Jeppestown, Transvaal.
Brown, Walter Bruce (address wanted).
Brown, William Bridgman, M.A., Griffithville, Queenstown, Cape.
Brown, Very Rev. W. Gore, The Rectory, Pretoria.
Brown, William M., Fortescue Road, Yeoville, Johannesburg.
Brownlee, John Innes, M.B., C.M., Alexandra Road, King William's Town, Cape.
Bruce-Bays, James Thomas, M.D., M.R.C.S., Grahamstown, Cape.
Brune, Rev. Richard, P.O. Box 41, Kimberley, Cape.
*Buchan, James, Assistant Resident Engineer, Umtali. Rhodesia.
Burke, Edmund Colpoys Lardner, B.A., 185, Du Toit's Pan Road, Kimberley, Cape.
Burroughs, Herbert John, c/o Drawing Office, Engineer-in-Chief's Department, South African Railways, Johannesburg.
Burt, Miss A., B.A., The Hermitage, Grahamstown, Cape.

Caldecott, W. A., B.A., D.Sc., F.C.S., P.O. Box 67, Johannesburg.
Calverley, Major E. L., Guelph College, Toronto, Ontario, Canada.
Cameron, Rt. Rev. William Mouatt, M.A., D.D., Coadjutor-Bishop of Cape Town.
*†Campbell, Allan McDowell McLeod, B.A., Resident Engineer, South African Railways, Schoombie.
Carlson, K. A., Forestry Division, Department of Agriculture, Bloemfontein.
Carter, Thomas Lane, Hammond, Louisiana, U.S.A.
Casalis, George Arnaud, M.B., C.M., S.A. Mutual Buildings, Darling Street, Cape Town.
Castro, Alvaro de Saldanha e., Beira, P.E. Africa.
Cattell, E. J., Chamber of Commerce, Cape Town.
†Cazalet, Percy, P.O. Box 32, Denver, Transvaal.
†*Champion, Ivor Edward (address wanted).*
Cheesman, H. G., The Eastern and South African Telegraph Company, Ltd., Cape Town.
Christie, James John, Grove, Hay Division, Cape.
Chubb, E. C., F.Z.S., F.E.S., P.O. Box 240, Bulawayo, Rhodesia.
Chute, Henry Macready, M.R.C.S., L.R.C.P. Edin., Ayliff Street, King William's Town, Cape.
Clark, John, M.A., LL.D., Professor of English Language and Literature, South African College, Cape Town.
*Clarke, W. E. C., M.A., Education Department, Pretoria.
Clarkson, R., Rietfontein "A," Ltd., P.O. Germiston, Transvaal.
Coghill, Douglas, Government Analytical Laboratory, Cape Town.
Cohen, Walter P., F.R.P.S., Hon. Sec., Johannesburg Field and Naturalists' Club, P.O. Box 68, Johannerbusg.
Colbert, William, British South African Dynamite Factory, Modderfontein, Transvaal.
*Colley, John, M.I.Mech.E., Indwe Mines, Cape.
Collie, J., Craigwan, Park Road, Bloemfontein.
Collins, Ernest A. E., 66, Pritchard Street, P.O. Box 723, Johannesburg.
Collins, M. R., P.O. Box 78, Potchefstroom, Transvaal.
*Connolly, R. M., P.O. Box 862, Johannesburg.
Cook, George W., B.Sc., Normal School, Bloemfontein.
Cooper, Arnold W., J.P., F.R.M.S., Richmond, Natal.
Cooper, Fred. W., Public Library, Port Elizabeth, Cape.
Cordeaux, Herbert J. C., Oxford Chambers, East London, Cape.
Corder, William James, P.O. Box 433, Cape Town.
*Corstorphine, G. S., PhD., B.Sc. (Pres. B., 1904), P.O. Box 1758, Johannesburg.
*Cory, Professor George Edward, M.A., Rhodes University College, Grahamstown, Cape.
Couper, Lindley Clyde, Equitable Life Insurance Co., P.O. Box 250, Cape Town.
Court, S. E., c/o Royal Statistical Society, London.
†Coutts, John Morton Sim, M.D., L.R.C.P., D.P.H., M.R.C.S., 88, Highbury New Park, London, N., England.

Cox, Douglas Brenton, South African Railways, Pietermaritzburg, Natal.
*Cox, Walter Hubert, Royal Observatory, near Cape Town.
Craib, David, M.A., Education Department, Cape Town.
Crawford, David Chalmers, M.A., B.Sc., B.Sc.Agr., Elsenburg, Mulder's Vlei, Cape.
*CRAWFORD, LAWRENCE, M.A., D.Sc., F.R.S.E. (Vice-President), Professor of Mathematics, South African College, Cape Town.
Crockett, John, 10, Transvaal Bank Buildings, Johannesburg.
Crofts, Donnelly Graham, Cadastral Survey Department, Nairobi, British East Africa.
Croghan, Edward H., F.C.S., P.O. Box 2187, Johannesburg.
†CULLEN, WILLIAM (GENERAL SECRETARY, 1905-1908), Dynamite Factory, Modderfontein, Transvaal.
Curlewis, Hon. Mr. Justice J. C., Judges' Chambers, P.O. Box 442, Johannesburg.
Curnow, Robert, Post Office, Nigel, Transvaal.
Currie, Dr. H. B., c/o Smit and Quartz Streets, Hospital Hill, P.O. Box 1102, Johannesburg.
Currie, O. J., M.B., M.R.C.S., Claremont, near Cape Town.
Cursons, W. E., P.O. Box 1176, Johannesburg.
Cuthbert, James R., Railway Education Officer, Stellenbosch, Cape.

Dale, Hubert, P.O. Box 13, Johannesburg.
Dalrymple, Hon. W., P.O. Box 2927, Johannesburg.
Davenport, William John, P.O. Box 1183, Johannesburg.
Davies, Dr. Howell, 389, St. Andries Street, Pretoria.
Davies, I. Hubert, M.I.E.E., M.I.M.E., A.M.I.C.E., P.O. Box 1386, Johannesburg.
Davis, Frederick H., B.Sc., M.I.E.E., P.O. Box 1934, Johannesburg.
†DAVY, J. BURTT, F.L.S., F.R.G.S., Government Botanist and Agrostologist, Department of Agriculture, P.O. Box 434, Pretoria.
Davy, Mrs. J. Burtt, P.O. Box 434, Pretoria.
Dessauer, A. von, M.E., P.O. Box 2083, Johannesburg.
Devlin, James Edward, F.C.S., Hazeldene, Baird Street, Uitenhage.
Dickie, Andrew (address wanted).
Dickson, George A. Hamilton, A.R.I.B.A., Trust Buildings, Johannesburg.
Dobson, Professor J. H., P.O. Box 1176, Johannesburg.
Dodd, Benjamin Herbert, M.A., "Daily Dispatch" Office, East London, Cape.
Dodd, Michael, P.O. Box 1197, Johannesburg.
Dodds, William John, M.D., D.Sc., Valkenberg, Mowbray, near Cape Town.
Dodt, J. J., National Museum, Bloemfontein.
Drege, I. L., Port Elizabeth, Cape.
Druce, P. M., B.A., The College, Potchefstroom, Transvaal.
*Drury, Edward Guy Dru, M.D., B.S., D.P.H., Graham's Town, Cape.

Duerden, James E., M.Sc., Ph.D., A.R.C.S., Professor of Zoology, Rhodes University College, Graham's Town, Cape.
Dumat, Frank C., F.R.A.S., P.O. Box 370, Johannesburg.
Duncan, A., P.O. Box 1214, Johannesburg.
Duncan, Patrick, C.M.G., Sauer's Buildings, Johannesburg.
Dunkerton, E. B., c/o Messrs. Lennon, Ltd., West Street, P.O. Box 266, Durban, Natal.
Dunn, William J., 48, Corrie Street, Jeppestown, Johannesburg.
Durham, James, Consolidated Gold Fields Office, London.
†Duthie, George, M.A., F.R.S.E. (Pres. D.), Director of Education, Salisbury, Rhodesia.
Dutton, J. H., Maseru, Basutoland.

Eaton, Hugh Godrich, 1, Main Road, Rosebank, near Cape Town.
Eaton, William Arthur, 74, St. George's Street, Cape Town.
Edwards, Charles J., c/o Messrs. Heynes, Mathew & Co., Cape Town.
†Engelenburg, Dr. F. V., Editor "De Volksstem," Pretoria.
Erskine, J. K., P.O. Box 88, Benoni, Transvaal.
Evans, Iltyd Buller Pole, M.A., B.Sc., F.L.S., Chief of the Division of Plant Pathology, Department of Agriculture, P.O. Box 434, Pretoria.
Evans, Lewis, P.O. Box 1032, Johannesburg.
Evans, Maurice Smethurst, Hillcrest, Berea, Durban, Natal.
Evans, Samuel, 79, Nugget Street, Johannesburg.
Everard, Horace Nathaniel, M.D., Ermelo, Transvaal.
Eyles, Fred., F.L.S., M.L.C. (Pres. C.), per private bag, Mazoe, Rhodesia.

Falck, G. D. A., 100, Zastron Street, Bloemfontein.
Farrar, Edward, P.O. Box 1242, Johannesburg.
Farrar, Sir George, Bart., M.L.A., P.O. Box 305, Johannesburg.
Feetham, R., Sauer's Buildings, c/o Loveday and Market Streets, Johannesburg.
Ferguson, E. W., P.O. Box 1066, Johannesburg.
Firks, Miss E. M., Normal College, Bloemfontein.
Fisher, J. S., Inspector of Mines Office, Winchester House, P.O. Box 1132, Johannesburg.
Fitchat, H., Albany House, Graham's Town, Cape.
Fitzpatrick, Sir J. Percy, K.C.M.G., M.L.A., Hohenheim, Parktown, Johannesburg.
*Flack, Rev. Francis Walter, M.A., R.D., St. Paul's Rectory, Port Elizabeth, Cape.
Flanagan, Henry George, F.L.S., Prospect Farm, Komgha, Cape.
*Fletcher, J., Borough Engineer, Durban, Natal.
*Flint, Rev. William, D.D. (Pres. D., 1910), Wolmunster Park, Rosebank, near Cape Town.
*Flowers, Frank, F.R.G.S., F.R.A.S., P.O. Box 1878, Johannesburg.
Foakes, Jervis E., Chief Government Inspector of Explosives, 75, Parliament Street, Cape Town.
Fogarty, Rev. N. W., Director, Government Industrial School, Maseru, Basutoland.

Foote, J. A., F.G.S., F.E.I.S., Government School, Troyeville, Transvaal.
Forrest, George, Boys' High School, Queen's Town, Cape.
Fox, George C., P.O. Box 2567, Johannesburg.
Frames, Charles, Port Elizabeth, Cape.
Frames, Minett E., F.G.S., P.O. Box 8, Johannesburg.
Frames, P. R., P.O. Box 189, Johannesburg.
Francke, Max, Berlin, W., 15, Dusseldorfer-strasse, 8, Germany.
†Frankenstein, Miss Adelia, B.A., 9, Knight Street, Kimberley, Cape.
Franks, Sir Kendal, C.B., M.A., M.D., P.O. Box 1858, Johannesburg.
Fraser, Dr. A. T., Pietermaritzburg, Natal.
Fremantle, Henry Eardley Stephen, M.A., F.S.S., M.L.A., Bedwell Cottage, Rosebank, Cape.
Fricker, Robert G. (address wanted).
Friedmann, J., Central Pharmacy, Bloemfontein.
Friel, Dr. A. R., P.O. Box 4299, Johannesburg.
*Fuhr, Harry A., A.M.I.C.E., Public Works Department, King William's Town, Cape.
Fuller, W. H., Chairman, Public Library, East London, Cape.

Gairdner, Dr. J. Francis R., 736, Church Street, Arcadia, Pretoria.
*Galpin, Alfred Carter, P.O. Box 14, Graham's Town, Cape.
Galpin, Ernest Edward, F.L.S., c/o Bank of Africa, Ltd., Queen's Town, Cape.
Gane, E. G., M.A. (Pres E., 1908), Kingswood College, Graham's Town, Cape.
Gane, Advocate P. C., The Grange, Graham's Town, Cape.
Garrett, F. M., P.O. Box 392, Bloemfontein.
*Gasson, William, F.C.S., Du Toit's Pan Road, Kimberley, Cape.
Gau, Julius, Silverhill, Greenfield Road, Kenilworth, near Cape Town.
Gellatly, John T. B., M.I.C.E., Bongolo Waterworks, Queen's Town, Cape.
*Gilchrist, John Dow Fisher, M.A., D.Sc., Ph.D., F.L.S. (General Secretary, 1903-1908), Professor of Zoology, South African College, Cape Town.
Gilchrist, W., Mariendahl, Mulder's Vlei, Cape.
*Gill, Sir David, K.C.B., LL.D., D.Sc., F.R.S., F.R.S.E. (President, 1903), Athenæum Club, London, England.
*Gillespie, John, c/o Messrs. Pauling & Co., Broken Hill, Rhodesia.
Ginsberg, Franz, P.O. Box 3, King William's Town, Cape.
Glenday, R., A.M.I.C.E., Public Works Department, Bloemfontein.
Goatcher, Alfred Winton, Krom River, Beaufort West, Cape.
*Godfrey, J. J., c/o Sociedad Hurlingham Club, San Martin, 121, Buenos Aires.
Godfrey, Rev. James Robert, 140, Bloed Street, Pretoria.
†Godfrey, Rev. Robert, M.A., Pirie Mission Station, King William's Town, Cape.

Goetz, Rev. E., S.J., M.A., F.R.A.S. (Pres. A), The Observatory, Bulawayo.
Goffe, E., P.O. Box 619, Johannesburg.
Goldmann, Richard, M.L.A., P.O. Box 2424, Johannesburg.
GOOLD-ADAMS, Sir HAMILTON, G.C.M.G., C.B. (PRESIDENT, 1909). Army and Navy Club, Pall Mall, London, S.W., England.
Gorges, Edmond Howard Lacam, Secretary for the Interior, Pretoria.
Graham, Kenneth L., Geldenhuis Deep, Ltd., P.O. Cleveland, Transvaal.
Graham, Hon. Mr. Justice Thomas Lyndoch, K.C., Graham's Town, Cape.
Grant, Charles C., M.A., Education Department, Bloemfontein.
Gray, Charles Joseph, Mines Department, P.O. Box 401, Pretoria.
Gray, James, P.O. Box 3427, Johannesburg.
Gray, Rev. James, Trinity Manse, Graham's Town, Cape.
Greathead, W. H., A.M.I.C.E., P.O. Box 4751, Johannesburg.
Grimmer, Irvine Rowell, Assistant General Manager, De Beers Consd. Mines, Ltd., Kimberley, Cape.
Grubb, Ernest, A.M.I.C.E., Town Hall, Graham's Town, Cape.
Gunn, Hugh, M.A. (Pres. III., 1900), Brora, Sutherlandshire, Scotland.
Gunning, J. W. B., Ph.D., Zoological Gardens, Pretoria.
†Gutsche, Phillipp, M.D., Villa Torrita, King William's Town, Cape.
Gyde, C. J., Public Works Department, Cape Town.

Haagner, Alwyn K., F.Z.S., Zoological Gardens, Pretoria.
Haarburger, Ivan H., Bloemfontein.
†Haarhoff, Daniel Johannes, J.P., Market Street, Kimberley, Cape.
*HAHN, PAUL DANIEL, M.A., Ph.D. (PRESIDENT, Pres. A., 1903), Professor of Chemistry and Metallurgy, South African College, Cape Town.
Hall, A. L., Geological Survey, P.O. Box 401, Pretoria.
Hall, Carl, A.M.I.C.E., F.G.S., 28, Club Arcade, Durban, Natal.
Hall, R. N., F.R.G.S. (Pres. B.). P.O. Box 595, Bulawayo.
Halm, J. K. E., Ph.D., Royal Observatory, Cape.
Halse, Walter, Armadillo Creek, Vryburg, Cape.
Hamilton, J. G., M.V.O., P.O. Box 1048, Johannesburg.
Hammer, A., 441, Burger Street, Pietermaritzburg, Natal.
*Hancock, H., A.M.I.C.E., P.O. Box 192, Klerksdorp, Transvaal.
†Hancock, Strangman, M.Amer.I.M.E., Kennel Holt. Cranbrook, Kent, England.
Harger, Harold Scott, 4, Green's Buildings, P.O. Box 1945, Johannesburg.
Harries, W. M., P.O. Box 1167, Johannesburg.
Harris, Lionel, M.E., B.Sc., 113, Sivewright Avenue, Doornfontein, P.O. Box 1311, Johannesburg.
†Hartley, A. H., P.O. Box 1096, Johannesburg.
Hatchard, John George, F.R.A.S., P.O. Box 505, Bloemfontein.
*Heatlie, Arthur, B.A., M.I.C.E., Engineer-in-Charge, Ceres Road to Ceres Railway, Ceres, Cape.

Helmore, William Holloway, 23, Jones Street, Kimberley, Cape.
Henderson, Rev. J., M.A., Lovedale, Cape.
Henderson, Dr. J. McClelland, P.O. Box 1146, Johannesburg.
*Henkel, J. S., Conservator of Forests, Knysna, Cape.
Henry, M., Government School, P.O. Box 37, Heidelberg, Transvaal.
Herdman, G. W., M.A., M.I.C.E., Public Works Department, P.O. Box 439, Pretoria.
Herford, Rev. W. L., The Rectory, Maseru, Basutoland.
Heron, Eden, Department of Agriculture, Lourenço Marques.
Hewetson, W. M., M.B., D.P.H., J.P., Wankie, Southern Rhodesia.
Hewitt, John, B.A., Director of the Albany Museum, Graham's Town, Cape.
Heymann, Alexander, M.Ph., M.Ch., M.A., P.O. Box 3427, Johannesburg.
Heymann, Richard, P.O. Box 2425, Johannesburg.
Heymans, Dr. G. M. A., Pretoria.
Heywood, Arthur William, Conservator of Forests, Pietermaritzburg, Natal.
Higgins, Frederick William, Greenwood Park, near Durban, Natal.
Hind, Robert, "The Journal" Office, Graham's Town, Cape.
Hintrager, Dr. O. R., Windhuk, German South-West Africa.
Hoernlé, Professor Reinhold Friedrich Alfred, M.A., B.Sc., South African College, Cape Town.
Hofmeyr, H. J., P.O. Box 3357, Johannesburg.
Holford, W. G., P.O. Box 2927, Johannesburg.
Holm, A., General Manager, Experimental Farm, Potchefstroom, Transvaal.
Holtby, A. C., M.I.E.E., P.O. Box 4336, Johannesburg.
Honnold, W. L., P.O. Box 2269, Johannesburg.
*Horne, William James, A.M.I.E.E., Education Department, Pretoria.
Horwood, C. Baring, F.G.S., A.R.S.M., A.I.M.M., A.M.I.C.E., Rand Club, P.O. Box 1032, Johannesburg.
Horwood, C. H. Russell, B.A., P.O. Box 105, Queen's Town, Cape.
Hosken, Richard, P.O. Box 667, Johannesburg.
Hosking, Charles, Town Engineer's Office, P.O. Box 106, Krugersdorp, Transvaal.
*Hough, Samuel Sydney, M.A., F.R.S., Astronomer Royal, Royal Observatory, near Cape Town.
Houghton, K. A. Hobart, B.A., Lovedale, Cape.
Howard Charles W., B.A., F.E.S. (Vice-President), Department of Agriculture, Lourenço Marques.
Howard, Robert Nesbit, M.R.C.S., L.R.C.P., L.S.A., F.R.M.S., O'okiep, Namaqualand, Cape.
Hudson, Miss Lilian Elizabeth, B.A., 24a, Marlborough House, Beit Street, Doornfontein, Transvaal.
Hudson, Walter Edward, P.O. Box 189, Johannesburg.
Hughes, George Robert, Under-Secretary for Lands, Pretoria.
Hulsteyn, Sir Willem van, P.O. Box 46, Johannesburg.

†Humphrey, William Alvara, B.A., Ph.D., F.G.S., P.O. Box 401, Pretoria.
Hurley, Fred Arthur, Irrigation Department, Pretoria.
Hurtzig, G., Gwelo, Rhodesia.
Hutt, Ernest W., P.O. Box 2, Randfontein, Transvaal.
HYSLOP, JAMES, D.S.O., M.B., C.M. (PRESIDENT, 1907), Government Asylum, Pietermaritzburg, Natal.

Imrie, George James, Forestry Plantation, Ermelo, Transvaal.
Innes, Hon. Justice Sir James Rose, K.C.M.G., B.A., LL.B., High Court of Appeal, Cape Town.
*INNES, ROBERT T. A., F.R.A.S., F.R.S.E. (GENERAL SECRETARY, 1909-1911), The Observatory, Johannesburg.
Innes, Mrs. R. T. A., The Observatory, Johannesburg.
Inskipp, Percy S., Bulawayo.
Institute of Government Land Surveyors, 6, Church Square, Cape Town.
Irvine, Dr. L. G., P.O. Box 320, Johannesburg.

Jack, J. Noble, Gloria, Caledon, Cape.
JACOTTET, Rev. E., Morija, Basutoland.
Jagger, J. W., F.S.S., M.L.A., St. George's Street, Cape Town.
Jameson, Rt. Hon. Sir Leander Starr, Bart., C.B., M.D., L.R.C.S., L.S.A., M.L.A., Westbrooke, Rondebosch, near Cape Town.
Jeffery, John, Standard Bank, P.O. Box 40, Cape Town.
Jennings, Hennen, Barney House, 1626, Rhode Island Avenue, Washington, U.S.A.
Jeppe, J., P.O. Box 311, Johannesburg.
*Johns, J. Harry, A.M.I.C.E., M.I.M.M., Royal Colonial Institute, Northumberland Avenue, London, W.C.
Johnson, Edward H., P.O. Box 134, East Rand, Johannesburg.
Johnson, H. Luttman, Rand Club, P.O. Box 1032, Johannesburg.
Johnson, Tom, Ferreira Deep, Johannesburg.
Johnson, W., L.R.C.P., L.R.C.S., Aliwal Street, Bloemfontein.
Johnson, Professor W. S., M.A., Grey University College, Bloemfontein.
Jones, Ernest Hope, Control and Audit Office, Pretoria.
Jorissen, Dr. E., Louth's Buildings, Salisbury, Rhodesia.
Joubert, M. J., B.Sc. Agr., Department of Agriculture, Bloemfontein.
Junod, Rev. Henri A., St. Blaise, Canton de Neuchatel, Switzerland.
JURITZ, CHARLES FREDERICK, M.A., D.Sc., F.I.C. (GENERAL SECRETARY, 1910-1911, Pres. II., 1909), Chief of the Division of Chemistry, Department of Agriculture, Government Analytical Laboratory, Cape Town.

Kanthack, Francis Edgar, A.M.I.C.E., Director of Irrigation, Parliament Street, Cape Town.
Kaufmann, Siegmund, M.D., Prieska, Cape.
Keay, David Doig, Department of Justice, Pretoria.
Kellner, Bernhard Otto, M.D., Aliwal Street, Bloemfontein.

Kennedy, John William James Clark, P.O. Box 84, Standerton, Transvaal.

†Kensit, Miss H. M. L., B.A., Sherwood, Kenilworth, near Cape Town.

Kent, Professor Thomas Parkes, M.A., South African College, Cape Town.

Kidd, Professor Arthur Stanley, M.A., Rhodes University College, Graham's Town, Cape.

King, Austin, Director of Mines, Macequeçe, Portuguese East Africa.

King, R. P. H., P.O. Box 365, Johannesburg.

Kirkman, John, Esperanza, Natal.

Kirkman, Hon. Thomas, Croftlands, Esperanza, Natal.

Kisch, C. H. M., P.O. Box 668, Johannesburg.

Kitching, Charles McGowan, B.A., M.D., B.S., 6, Hof Street, Cape Town.

Kipps, George B., F.R.G.S., South African College School, Cape Town.

*†Knapp, Arthur D., Chikondi Estate, Neno Post Office, British Central Africa.

Kolbe, Rev. Frederick Charles, B.A., D.D., St. Mary's Presbytery, Cape Town.

Kotze, Robert W. N., B.A., Winchester House, Johannesburg.

Kynaston, H., M.A., F.G.S., P.O. Box 401, Pretoria.

Lake, Henry Lawrence, Public School, Dynamite Factory, Modderfontein, Transvaal.

Lamont, J., Braemar Villa, Porter Street, Queen's Town, Cape.

Lance, Hon. Senator W. F., P.O. Box 744, Johannesburg.

Langermann, J. W. S., M.L.A., P.O. Box 253, Johannesburg.

Laschinger, E. J., B.A., P.O. Box 149, Johannesburg.

Lavenstein, L. H., P.O. Box 4480, Johannesburg.

Lawrence, Frederick James, Resident Magistrate, Steytlerville, Cape.

Laws, Harry Edwin, B.Sc., F.I.C., Cooper Laboratory for Economic Research, Watford, England.

Leask, Tom., junr., P.O. Box 3, Klerksdorp, Transvaal.

Leech, Dr. John Richard (address wanted).

Leeds, R. Q., P.O. Box 928, Johannesburg.

Leendertz, Miss R., Botanical Association, Transvaal Museum, Pretoria.

Lees, W., Alali Farm, Matopos, Rhodesia.

Legat, C. E., P.O. Box 434, Pretoria.

Legg, William Andrew, M.I.C.E., P.O. Box 1621, Cape Town.

LEHFELDT, ROBERT A., B.A., D.Sc. (GENERAL TREASURER, 1909-1910), Professor of Physics, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.

Leighton, James, F.R.H.S., P.O. Box 86, King William's Town, Cape.

Leitch, Donald Calder, M.I.C.E., P.O. Box 1703, Johannesburg.

Leiter, Miss Susan B., B.A., Huguenot College, Wellington, Cape.

Lennox, Rev. John, M.A., Lovedale, Cape.

*Lenz, Otto, P.O. Box 92, Johannesburg.
Leslie, T. N., C.E., F.G.S., P.O. Box 23, Vereeniging, Transvaal.
Leviseur, M., 17, Margraff Street, Bloemfontein.
Lewis, Leon, P.O. Box 617, Johannesburg.
Lewis, Mrs. Helen R., P.O. Box 617, Johannesburg.
*Lindley, J. Bryant, C.M.G., M.A., LL.B., Claremont, near Cape Town.
Littlewood, E. T., M.A., B.Sc., Boys' High School, Wynberg, Cape.
Logeman, William H., M.A., South African College, Cape Town.
*Logeman, Professor William Sybrand, L.H.C., B.A., South African College, Cape Town.
Long, Dr. E. H., Maseru, Basutoland.
Lorentz, Henri, P.O. Box 55, Johannesburg.
Loubser, M. M., Port Elizabeth, Cape.
Lounsbury, Charles Pugsley, B.Sc., F.E.S., Chief of the Division of Entomology, Department of Agriculture, Pretoria.
Lowden, Thomas Wedgewood, 7, Victoria Buildings, Krugersdorp, Transvaal.
Lucas, J. C., P.O. Box 716, Johannesburg.
*Lunt, Joseph, D.Sc., F.I.C., F.R.A.S., Royal Observatory, near Cape Town.
Lyle, James, M.A., Grey College School, Bloemfontein.
*Lynch, Major F. S., J.P., Kimberley Waterworks Co., Ltd., Kimberley, Cape.
Lyne, Robert Nunez, F.L.S., F.R.G.S., Director of Agriculture, P.O. Box 255, Lourenço Marques.

Maasdorp, Hon. Justice Sir Andries F., 40, Elizabeth Street, Bloemfontein.
McArthur, Duncan Campbell, M.R.C.S., L.R.C.P., Taungs, Cape.
Macaulay, Dr. Donald, Cleveland, Transvaal.
*McBean, D. Moore, 16, Main Street, Kimberley, Cape.
McCallum, William, P.O. Box 4889, Johannesburg.
McCRAE, J., Ph.D., F.I.C. (GENERAL TREASURER, 1908), P.O. Box 1080, Johannesburg.
McDonald, Archibald Urry, Native Affairs Dept., Salisbury, Rhodesia.
Macdonald, G., Government School, Ladybrand, Orange Free State.
*Macdonald, William, M.Sc., Ph.D., M.S.Agr., F.R.S.E., Pretoria Club, Pretoria.
McEwen, T. S., A.M.I.C.E., South African Railways, Cape Town.
**Macfarlane, Donald, M.I.C.E.* (*address wanted*).
Macfarlane, Dr. M., Government Medical Officer, Leribe, Basutoland.
Macfadyen, Professor William Allison, M.A., LL.D., Transvaal University College, Pretoria.
McFeggans, Alexander, Umtata, Cape.
McGaw, James, P.O. Box 4280, Johannesburg.
Macgregor, J. C., Leribe, Basutoland.
McKENZIE, ARCHIBALD, M.D., C.M., M.R.C.S., Glen Lyon, Berea, Durban, Natal.

Mackinlay, Andrew Grieve, C.E., M.S.I., District Engineer, South African Railways, Ladysmith, Natal.
McLaren, W. A., P.O. Box 1209, Johannesburg.
*Macmuldrow, W. G. P., P.O. Box 95, Salisbury, Rhodesia.
Macrae, H. J., P.O. Box 817, Johannesburg.
Macvicar, Neil, M.D., C.M., D.P.H., Lovedale, Cape.
Madge, Captain Charles A., P.O. Box 4303, Johannesburg.
Malan, Hon. François Stephanus, B.A., LL.B., M.L.A., Minister of Education, Cape Town.
Malherbe, H. L., P.O. Box 208, Pretoria.
Mallinick, P., P.O. Box 48, Johannesburg.
Mally, Charles William, M.Sc., Division of Entomology, Department of Agriculture, Cape Town.
Marchand, Rev. Bernard P. J., B.A., Clairvaux, Rondebosch, Cape.
Marks, Samuel, Hatherley Buildings, P.O. Box 379, Pretoria.
Marks, Mrs. Elia, P.O. Box 382, Johannesburg.
*Marloth, Rudolf, M.A., Ph.D. (Pres. B.. 1903), P.O. Box 359, Cape Town.
Marriott, William Edward, Buvie, P.O. York, Natal.
Marshall, W. S., P.O. Box 3055, Johannesburg.
Martini, J. D., P.O. Box 34, Beira, Portuguese East Africa.
Masson, J. L., Pietermaritzburg, Natal.
Maynard, George Darell, M.R.C.S., L.R.C.P., F.R.C.S.E., P.O. Box 1128, Pretoria.
Maufe, H. B., B.A., F.G.S., P.O. Box, 168, Bulawayo.
Melle, G. J. McCarthy, M.B., C.M., Robertson, Cape.
Mellor, Edward T., D.Sc., F.G.S., Geological Survey Office, P.O. Box 401, Pretoria.
*Melvill, E. H. V., P.O. Box 719, Johannesburg.
*Menmuir, R. W., A.M.I.C.E., Town Engineer, Woodstock, near Cape Town.
MENNELL, FREDERIC PHILIP, F.G.S., Rhodesia Museum, Bulawayo, Rhodesia.
Merensky, Hans, P.O. Box 1557, Johannesburg.
*†METCALFE, Sir CHARLES, Bart., M.I.C.E. (PRESIDENT, 1904, Pres. C., 1903), Rhodes Buildings, Cape Town.
Miller, Allister M., The Swaziland Corporation, Ltd., Mbabane, Swaziland.
Minor, Miss Jessie E., Huguenot College, Wellington, Cape.
Miolee, W. F., P.O. Box 362, Bulawayo.
**Mirrlees, W. J. (address wanted).*
Mitchell, James Alexander, M.B., Ch.B., D.P.H., 55, Parliament Street, Cape Town.
Mitchell. John Stevenson, Queen's Town, Cape.
Moffat, Henry Alford, B.A., F.R.C.S., L.R.C.P., Norwich Union Buildings, St. George's Street, Cape Town.
MOFFAT, HOWARD UNWIN, P.O. Box 592 Bulawayo, Rhodesia.
MOIR, JAMES, M.A., D.Sc., F.C.S., Mines Department, Johannesburg.
MOLYNEUX, A. J. C., F.G.S., F.R.G.S. (Vice-President, Pres. B.), P.O. Box 562, Bulawayo, Rhodesia.
Morice, Advocate George T. B.A., P.O. Box 480, Johannesburg.

Morris, James, City Deep Gold Mining Co., Johannesburg.
Morrison, F. T., Nyassa, Wilmer Street, Graham's Town, Cape.
Moss, J., c/o E. Basch & Co., Bulawayo.
Mudie, C. J., Superintendent of Education, Pietermaritzburg, Natal.
*Muir, Thomas, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. (President, 1910), Education Department, Cape Town.
Muirhead, James Muirhead Potter, J.P., F.R.S.E. F.C.I.S., F.S.S., P.O. Box 1161, Cape Town.
Muller, John, B.A., F.C.S., Senior Chemist, Government Analytical Laboratory, Cape Town.
Mundy, H. Godfrey, Salisbury, Rhodesia.
Murray, George Alfred Everett, M.D., F.R.C.S., L.R.C.P., P.O. Box 105, Johannesburg.

Nathan, Sir Matthew, 36, St. George's Court, Gloucester Road, London, S.W., England.
Nauta, Prof. R. D., South African College, Cape Town.
Neilson, A. M., Manager, Safco Fertilizers Co., Umbilo, Natal.
Neilson, W. D., M.A., Public School, Graham's Town, Cape.
Nevill, Edmund Neville, F.R.S., F.I.C., F.C.S. (Pres. A., 1907), Government Observatory, Durban, Natal.
*Newdigate, William, c/o De Beers Consd. Mines, Ltd., Kimberley, Cape.
Nichol, Thomas Thompson (address wanted).
Nicholas, W. H. (address wanted).
*Nicholson, Colonel George Taylor, M.I.C.E., Resident Engineer, Docks, Cape Town.
Nicholson, J. Greg (address wanted).
Niven, A. Mackie, P.O. Box 2365, Johannesburg.
Nixon, Edward John, M.R.C.S., L.R.C.P., P.O. Box 57, Heidelberg, Transvaal.
Nixon, W. G. C., 29, Cavendish Road, Yeoville, Johannesburg.
Noaks, E., M.A., "The Croft," Morgenrood Road, Wynberg, Cape.
Nobbs, Eric Arthur, Ph.D., B.Sc., F.R.H.S., Director of Agriculture, Salisbury, Rhodesia.
Noble, Miss, 143, Troye Street, Sunnyside, Pretoria.
*Northcroft, G. A., Margraf Street, Bloemfontein.

†Oats, Francis, F.G.S., Director, De Beers Consd. Mines, Ltd., Kimberley, Cape.
O'Brien, W. J., Pietermaritzburg, Natal.
O'Connor, James, Railway Hotel and Stores, Ashton, Cape.
Ogg, Professor Alexander, M.A., B.Sc., Ph.D., Rhodes University College, Graham's Town, Cape.
Oppenheimer, Ernest, P.O. Box 273, Kimberley, Cape.
O'Reilly, J. P., P.O. Box 53, Johannesburg.
Orford, Rev. Canon Horace William, Old St. Andrew's, Bloemfontein.
Orpen, Joseph Millerd, Holme-Leigh, Upper Oxford Street, East London, Cape.

*Orr, Professor John, B.Sc., A.M.I.C.E., P.O. Box 1176, Johannesburg.
Osborn, P. B., P.O. Box 1242, Johannesburg.

†Paisley, William, M.B., B.Ch., P.O. Box 127, Queen's Town, Cape.
Pakes, Dr. A. E. H. (address wanted).
Palmer, W. Jarvis, B.Sc.A., Department of Agriculture, Bloemfontein.
Papenfus, H. B., P.O. Box 5155, Johannesburg.
Pardy, Alexander, Elgin, Scotland.
Parfitt, A. E., Town Hall, Bloemfontein.
Park, Maitland H., M.A., LL.D., 1, Montrose Avenue, Orangezicht, Cape Town.
Parry, E. H., P.O. Box 164, Mines Department, Germiston, Transvaal.
*†Pattrick, C. B., A.M.I.C.E., P.O. Box 39, Springs, Transvaal.
Payne, Albert E., A.R.S.M., P.O. Box 193, Germiston, Transvaal.
Pearson, Henry Harold Welch, M.A., Sc.D., F.L.S. (Pres. C., 1910), Professor of Botany, South African College, Cape Town.
Peringuey, Louis, D.Sc., F.E.S., F.Z.S., Director South African Museum, Cape Town.
†Perold, A. J., B.A., Ph.D., Government Viticulturist, Belle Vue, Paarl, Cape.
Perrott, Robert R., Harbour Board, Port Elizabeth, Cape.
Petersen, Carl Olief, P.O. Box 4938, Johannesburg.
Petersen, H. T. (address wanted).
Pettman, Rev. Charles, The Parsonage, Queen's Town, Cape.
Pim, Howard, F.C.A. (General Treasurer, 1906-1907), P.O. Box 1331, Johannesburg.
Pim, Mrs. R. W., P.O. Box 1331, Johannesburg.
Pitts, John, P.O. Box 483, Johannesburg.
Posselt, F. W. T., Chief Native Commissioner's Office, Salisbury, Rhodesia.
Potts, George, M.Sc., Ph.D., Professor of Botany, Grey University College, Bloemfontein.
Preston, James (address wanted).
*Price, Sir Thomas R., K.C.M.G., P.O. Box 1038, Johannesburg.
Prior, Ferdinand, P.O. Box 1005, Johannesburg.
Purcell, William Frederick, M.A., Ph.D., C.M.Z.S., Bergvliet, Diep River, Cape Division.
Pym, Frank Arthur Oakley, Public Museum, King William's Town, Cape.

Quinan, Kenneth B., Chemist and Engineer, Cape Explosive Works, Somerset West, Cape.
Quinn, J. W., J.P., P.O. Box 1454, Johannesburg.

Rattray, George, M.A., D.Sc., F.R.G.S., Selborne College, East London, Cape.
Rawson, A., c/o Berning & Garner, Lusikisiki, Eastern Pondoland, Cape.
*Reeve, Thomas, Highbury, Heugh Road, Port Elizabeth, Cape.

Reid, Alexander William, M.D., C.M., Medical Officer of Health, Kimberley, Cape.
*REID, ARTHUR HENRY, F.R.I.B.A., F.R.San.I., 20, South African Chambers, St. George's Street, P.O. Box 120, Cape Town.
Reid, F. Murray, Morija, Basutoland.
Reimer, E., German Consul, P.O. Box 392, Pretoria.
Reinecke, T. G. R., B.A., Government Agricultural School, Potchefstroom, Transvaal.
*REUNERT, THEODORE, M.I.C.E., M.I.M.E. (PRESIDENT, 1905), P.O. Box 92, Johannesburg.
Reunert, Mrs. Theodore, P.O. Box 92, Johannesburg.
Reuter, Rev. Fritz L., Medigen, P.O. Duivel's Kloof, *via* Pietersburg, Transvaal.
†Reyersbach, Louis J., c/o Messrs. Wernher, Beit & Co., 1, London Wall Buildings, London, E.C.
Richardson, Sidney William Franklin, M.B., B.S., B.Sc., L.R.C.P., F.R.C.S., 2, Wale Street, Cape Town.
Rindl, Professor Max, Ing.D., Grey University College, Bloemfontein.
Rissik, Cor., P.O. Box 401, Johannesburg.
Ritchie, Professor William, M.A., South African College, Cape Town.
Robb, A. Moir, M.A., The High School, Kroonstad, Orange Free State.
*Roberts, Alexander William, D.Sc., F.R.A.S., F.R.S.E. (Pres. A., 1908), Lovedale, Cape.
Roberts, H. Keeling, M.R.C.V.S., P.O. Box 593, Pretoria.
Robertson, C. C., M.F., Department of Agriculture, Bloemfontein.
Robertson, John, Jammersberg Drift, Wepener, Orange Free State.
Robertson, William, M.R.C.V.S., Graham's Town, Cape.
Robson, T. Conyers, Salisbury Buildings, Von Brandis Square, Johannesburg.
Rodger, James, M.A., Education Office, Cape Town.
Rogers, Arthur William, M.A., Sc.D., F.G.S. (Pres. B., 1910), South African Museum, Cape Town.
Rogers, Rev. F. A., M.A., Bishopsbourne Cottage, Graham's Town, Cape.
Rogers, Dr. W. G., P.O. Box 1750, Johannesburg.
Rolfes, Carl, P.O. Box 1110, Johannesburg.
Ronaldson, J. H., P.O. Box 424, Salisbury, Rhodesia.
Rose, James Wilmot Andreas, A.M.I.C.E., South African Railways, Bloemfontein.
†Rose, John George, F.C.S., Government Analytical Laboratory, Cape Town.
Rosendorff, Arthur, P.O. Box 1242, Johannesburg.
Rouliot, G., P.O. Box 149, Johannesburg.
RUDGE, WILLIAM ARTHUR DOUGLAS, M.A. (Pres. I., 1909), Professor of Physics, Grey University College, Bloemfontein.
*Runciman, William, M.L.A., Simon's Town, Cape.
Russell, W. A., M.A., Education Department, Cape Town.

Salisbury, Clement W., P.O. Box 2015, Johannesburg.

Saner, C. B., A.I.M.E., P.O. Box 1145, Johannesburg.
Santhagens, Réné van E., M.Sc., Stellenbosch.
Sawer, Edward Reginald, M.A., B.Sc., Cedara, Natal.
Saxton, Walter T., M.A., F.L.S., South African College, Cape Town.
*Scaife, Thomas Earle, M.I.C.E., Breede River Irrigation Works, Burnholme, Robertson, Cape.
Schlesinger, Dr. J., P.O. Box 1829, Johannesburg.
Schmidt, Frederick Godfrey, No. 89, Sixth Avenue, New York City, New York, U.S.A.
Schmitt, C. O., P.O. Box 6404, Johannesburg.
*Schönland, Selmar, M.A., Ph.D., F.L.S., C.M.Z.S. (Pres. C., 1908), Professor of Botany, Rhodes University College, Graham's Town, Cape.
Schulze, Dr. Franz Karl, 29, Ayliff Street, King William's Town, Cape.
Schumacher, R. W., P.O. Box 149, Johannesburg.
SCHWARZ, ERNEST H. L., A.R.C.S., F.G.S. (Pres. B. and C., 1908), Professor of Geology, Rhodes University College, Graham's Town, Cape.
Scott, Herbert S., Education Department, Pretoria.
Sellar, John Nicol, M.L.A., P.O. Box 3102, Johannesburg.
Severn, Walter Dalrymple, A.R.C.S., F.C.S., Health Department, Parliament Street, Cape Town.
Shanks, Robert, 10, Graf Street, Johannesburg.
Shaw, W. H., P.O. Box 455, Germiston, Transvaal.
*Shores, J. W., C.M.G., M.I.C.E., South African Railways, Pietermaritzburg, Natal.
Sim, James, 81, Durban Street, King William's Town, Cape.
Sinclair, St. Clair Overbeek, M.A., F.C.S., Senior Chemist, Chemical Laboratory, Department of Agriculture, Pretoria.
Skead, C. G. H., P.O. Box 54, Port Elizabeth, Cape.
Skeels, C. S., B.A., c/o Mr. Skeels, Explosives Office, Johannesburg.
Skinner, W., Rietfontein "A," Ltd., P.O. Germiston, Transvaal.
Sloley, Sir Herbert, K.C.M.G., Resident Commissioner, Maseru, Basutoland.
*Smartt, Hon. Sir Thomas William, K.C.M.G., L.R.C.S.I., L.K.Q.C.P.I., M.L.A., Glen Bân, Stellenbosch, Cape.
Smith, F. Braybrooke, Secretary for Agriculture, P.O. Box 434, Pretoria.
Smith, James, M.A., Normal College, Cape Town.
Smith, Percival Frere, Rand Club, Johannesburg.
Smuts, C., P.O. Box 1088, Johannesburg.
Smuts, Hon. J. C., B.A., LL.B., Minister of the Interior, P.O. Box 1081, Pretoria.
Smyth, H. Warrington, Mines Department, Pretoria.
Snape, Alfred Ernest, M.Sc., A.M.I.C.E., M.R.San.I., Professor of Engineering, South African College, Cape Town.
Solly, Hubert Le Gay, A.M.I.C.E., Knor Hoek, Sir Lowry's Pass, Cape.
Solly, Mrs. Julia F., Knor Hoek, Sir Lowry's Pass, Cape.

Solomon, Hon. Justice Sir W. H., High Court of Appeal, Cape Town.
Somerville, A. J., M.A., College House, Graaff-Reinet, Cape.
Southwell, Miss Jessie (address wanted).
†Soutter, John Lyall, Arcadia, Pretoria.
†SPENCER, Dr. HENRY ALEXANDER, M.R.C.S., L.R.C.P., Middelburg, Transvaal.
Spengel, H., P.O. Box 3498, Johannesburg.
Sperryn, Arthur James, P.O. Box 1, Ermelo, Transvaal.
Spilhaus, William, c/o Messrs. W. Spilhaus & Co., Strand Street, Cape Town.
Spurway, E. J., M.A., Steynsburg, Cape.
Stainthorpe, Thomas William, A.M.I.C.E., Irrigation Department, Parliament Street, Cape Town.
Stallard, C. F., P.O. Box 5156, Johannesburg.
STANLEY, Professor GEORGE HARDY, A.R.S.M., M.I.M.E., P.O. Box 1176, Johannesburg.
Starkey, Samuel, Engineer-in-Chief's Office, South African Railways, Pietermaritzburg, Natal.
STEAD, ARTHUR, B.Sc., F.C.S., Government Laboratories, Bloemfontein.
Steedman, Miss E. C., M.A., Gando Farm, Gwelo, Southern Rhodesia.
Stephen, William, P.O. Box 2, Randfontein, Transvaal.
Stevens, J. D., P.O. Box 1782, Johannesburg.
Stevenson, Miss Elizabeth, B.A., Collegiate School, Port Elizabeth, Cape.
Stevenson, Sir Edmond Sinclair, Kt., M.D., Ch.D., F.R.C.S.E., Strathallan, Rondebosch, near Cape Town.
Stewart, G. A., City Engineer, Bloemfontein.
Strollreither, G. D., M.E., P.O. Box 1156, Johannesburg.
Stoneman, Miss Bertha, D.Sc., Huguenot College, Wellington, Cape.
*Stott, Clement H., F.G.S., M.S.A., P.O. Box 7, Pietermaritzburg, Natal.
†Strange, Harold F., P.O. Box 2527, Johannesburg.
Strange, Mrs. Harold F., P.O. Box 2527, Johannesburg.
Struben, A. M. A., A.M.I.C.E., P.O. Box 1228, Pretoria.
Stuart, James, Native Affairs Department, Pietermaritzburg, Natal.
Stubbs, J. W. H., P.O. Box 2, Randfontein, Transvaal.
Stucke, W. H., P.O. Box 2271, Johannesburg.
Sutton, Rev. F. J., M.A., Dale College, King William's Town, Cape.
Sutton, Hon. Sir George Morris, K.C.M.G., Fair Fell, Howick, Natal.
*Sutton, John Richard, M.A., Sc.D. (Pres. A., 1906). P.O. Box 142, Kimberley.
Syfret, S. B., B.A., M.B., B.C., Main Road, Mowbray, near Cape Town.

Tait, Alexander Coutts, Rubislaw, Belvedere Avenue, Cape Town.

†Tannahill, Thomas Findlay, M.D., C.M., D.P.H., Queen's Town, Cape.
Taylor, H. M., Government School, Fouriesburg, Orange Free State.
Taylor, Lionel E., P.O. Box 434, Pretoria.
Teasdale, Miss E. L., Government School, Maraisburg, Transvaal.
Tennant, Sydney Dennison, P.O. Box 132, Ermelo, Transvaal.
†THEILER, ARNOLD, C.M.G., M.D. (Vice-President), Director of Veterinary Research, P.O. Box 593, Pretoria.
Thomas, Walwyn, B.C., M.B., B.A., City Club, Cape Town.
Thompson, H., B.Sc., Government Agricultural School, Potchefstroom, Transvaal.
*Thompson, William Wardlaw, F.Z.S., Kimberley Cottage, Kalk Bay, Cape.
Thompson, George Ritchie, M.B., F.R.S.E., Kapteyn Street, Hospital Hill, Johannesburg.
Thomson, William, M.A., B.Sc., LL.D., F.R.S.E., University Offices, Queen Victoria Street, Cape Town.
Thorne, Sir William, Kt., Cape Town.
Thornton, Russel William, Government Agriculturist, Grootfontein, Middelburg, Cape.
Thurston, G. H., P.O. Box 67, Johannesburg.
Tietz, Heinrich, M.A., Ph.D., Buona Vista, Burham Road, Observatory Road, near Cape Town.
Tomory, D. M., M.B., C.M., D.P.H., Bloemfontein.
Tooke, W. Hammond (Pres. F., 1908), Graham's Town, Cape.
Tosh, William, M.I.M.E., P.O. Box 2392, Johannesburg.
*TOWNSEND, STEPHEN FRANK, C.E., Rhodesia Railways, Ltd., Bulawayo, Rhodesia.
Traill, David, M.A., M.B., Ch.M., B.Sc., Railway Medical Officer, Beaufort West, Cape.
Trevor, Tudor G., P.O. Box 401, Pretoria.
Trollip, W. L., Office of the Hon. the Administrator of the Cape Province, Cape Town.
Troup, James Macdonald, M.B., Ch.B., L.S.A., 230, Esselen Street, Sunnyside, Pretoria.
Tucker, William Kidger, C.M.G., P.O. Box 9, Johannesburg.
*Tudhope, Alfred Dryden, M.I.C.E., Office of the Assistant General Manager of Railways, Cape Town.
Tyers, F. G., B.A., The College, Potchefstroom, Transvaal.
Tyrrell, E. G. Harcourt, c/o Resident Magistrate, Greytown, Natal.
Tyson, Captain T., Director, De Beers Consd. Mines, Ltd., Kimberley, Cape.

Upton, Prescott, P.O. Box 1026, Johannesburg.

Van der Merwe, Prof. C. P., Victoria College, Stellenbosch, Cape.
Van der Merwe, C. P., Department of Agriculture, Bloemfontein.
Van der Riet, Berthault de St. Jean, M.A., Ph.D., Professor of Chemistry, Victoria College, Stellenbosch, Cape.
Van der Sterr, W. C., P.O. Box 1066, Johannesburg.
Van Oordt, J. F., B.A. (address wanted).

VAUGHAN, J. A., P.O. Box 1132, Johannesburg.
Verney, F. A., Maseru, Basutoland.
VERSFELD, W., B.A., B.Sc. (Assistant General Secretary), Government Analytical Laboratory, Cape Town.
*Viney, Arthur E., P.O. Box 3233, Johannesburg.
Von Oppell, Otto Karl Adolf, Rocklands Terrace, Upper Buitenkant Street, Cape Town.
Von Lindequist, His Excellency, Baron, Kurfurtendomm, 225, II Berlin, W., Germany.
Vyvyan, Rev. Thomas Grenfell, M.A., Poldhu, Richmond, Natal.

Waldron, Frank William, A.M.I.C.E., Parliament Street, Cape Town.
Walker, Rev. Prof. Thomas, M.A., LL.D., Litt.D., Vice-Chancellor of the University of the Cape of Good Hope, Victoria College, Stellenbosch, Cape.
Wall, B. P., Chief Engineer, S.A. Railways, Johannesburg.
Wallace, Robert Catherwood, S.A. Railways, Pretoria.
*Waller, A. H., A.M.I.C.E., F.R.Met.Soc., Voorspoed, Orange Free State.
*WALSH, ALBERT (GENERAL TREASURER), P.O. Box 39, Cape Town.
Walters, J. A. T., Dept. of Agriculture, P.O. Box 434, Pretoria.
WARREN, Prof. ERNEST, D.Sc., Natal Museum, Pietermaritzburg, Natal.
Watermeyer, Frederick Stephanus, P.O. Box 973, Pretoria.
Waterston, Jane Elizabeth, M.D., L.R.C.P., L.R.C.S.E., Parliament Street, Cape Town.
*Watkins, Arnold Hirst, M.D., M.R.C.S., M.L.A. (Pres. D., 1906), Ingle Nook, Kimberley, Cape.
Watkins-Pitchford, Lieut.-Col. H., F.R.C.V.S. (Pres. C., 1907), P.O. Box 282, Allerton, Pietermaritzburg, Natal.
Watkins-Pitchford, W., M.D., F.R.C.S., D.P.H., Allerton (P.O. Box 282), Pietermaritzburg, Natal.
Watt, Dugald Campbell, M.D., 131, Pietermaritzburg Street, Pietermaritzburg, Natal.
Weall, Horace Graham, Government Laboratories, Bloemfontein.
Webb, C. F., B.A., Royal Hotel, Plein Street, Johannesburg.
*Webb, H. H., M.I.M.M., 8, Old Jewry, London, E.C.
Weiskopf, Eric, Dynamite Factory, Modderfontein, Transvaal.
Welch, Rev. Sidney Read, B.A., D.D., Ph.D., St. Mary's, Bouquet Street, Cape Town.
Wessels, Hon. Justice Sir John W., B.A., LL.B., Pretoria.
*Whitaker, George Reginald, District Engineer, South African Railways, East London, Cape.
White, Miss Francis M., Trescoe, Cornwall Place, Wynberg, near Cape Town.
*WHITE, FRANKLIN, P.O. Box 334, Bulawayo, Rhodesia.
White, H. A., Roodepoort Central Deep, P.O. Box 114, Roodepoort, Transvaal.
White, Miss Henrietta Mary, B.A., Trescoe, Cornwall Place, Wynberg, near Cape Town.
White, Maurice, M.A., Zeerust, Transvaal.

*White-Cooper, William, M.A., F.R.I.B.A., Graham's Town, Cape.

Whitson, R. A., A.M.I.C.E., Public Works Department, Maseru, Basutoland.

Whitton, James Reid, Principal, Normal College, Cape Town.

Whitworth, W. S., Koffyfontein Diamond Mine, Orange Free State.

Wiener, Ludwig, F.R.G.S., Riebeek Street, P.O. Box 365, Cape Town.

Wilhelm, A. R. A., M.B., C.M., Barkly East, Cape.

Wilkinson, D., A.R.S.M., c/o S. Neumann & Co., Salisbury House, London, E.C.

Wilkinson, Herbert, B.A., Queen's College, Queen's Town, Cape.

Wilkinson, Professor J. A., M.A., F.C.S., P.O. Box 1176, Johannesburg.

Wille, Friedrich Adolf, M.D., Ch.B., D.P.H., 11, Derby Road, Bertrams, Johannesburg.

*Williams, Alpheus Fuller, B.S., Mining Engineer, De Beers Consd. Mines, Ltd., Kimberley, Cape.

Williams, Prof. D., B.Sc., Rhodes University College, Graham's Town, Cape.

*WILLIAMS, GARDNER F., M.A., LL.D. (PRESIDENT, 1906), 2201, R. Street, N.W. Washington, D.C., U.S.A.

Wilman, Miss M., McGregor Memorial Museum, Kimberley, Cape.

*Wilms, L. H., A.M.I.E.E., P.O. Box 88, East Rand, Transvaal.

Wilson, Allen, 32, Mutual Buildings, Johannesburg.

†Wilson, Arthur Marius, M.D., B.S., L.R.C.P., M.R.C.S., Jesmond House, Hof Street, Cape Town.

Wilson, Alfred William, P.O. Box 24, Langlaagte, Transvaal.

Windram, James Thomas, P.O. Box 3547, Johannesburg.

†Winterton, Albert Wyle, F.C.S., Lemoenfontein, near Beaufort West, Cape.

Wood, H. E., M.Sc. F.R.Met.S., Government Observatory, Johannesburg.

†Wood, James, M.A., P.O. Box 2, King William's Town, Cape.

Wood, John, P.O. Box 363, East London, Cape.

Wood, John Medley, Botanic Gardens, Durban, Natal.

Woolston, Professor J. H., B.A., Grey College, Bloemfontein.

Wright, H. J., Grey College School, Bloemfontein.

Young, Professor R. B., M.A., B.Sc., F.R.S.E., F.G.S., P.O. Box 1176, Johannesburg.

Young, T., M.A. Boys' High School, Sea Point, Cape.

Zwaan, W. de, P.O. Box 17, Pretoria.

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